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VOLUME 33 | DECEMBER, 1949 | NUMBER 5

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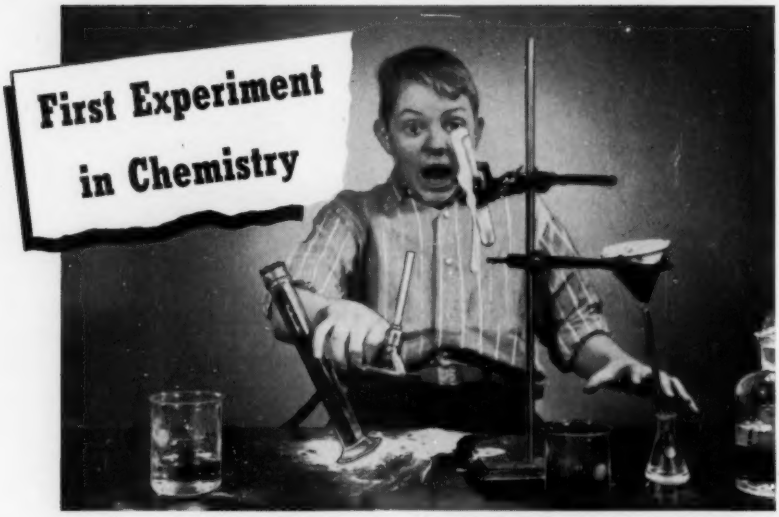

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SCIENCE EDUCATION

VOLUME 33 DECEMBER, 1949 NUMBER 5

SUMMARY OF THE RELATIVE ACHIEVEMENTS OF THE OBJECTIVES OF SECONDARY-SCHOOL SCIENCE IN A REPRESENTATIVE SAMPLING OF FIFTY-SIX MINNESOTA SCHOOLS *

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THE PROBLEM

THIS study has concerned itself with two general problems: the status of science instruction in the high schools of Minnesota, and the isolation of those factors inherent in the pupil or in the teaching situation that make for a better realization of the objectives of science instruction. The study was limited to the two secondary-school sciences: biology and chemistry.

The objectives of science instruction as reported in the literature on science education were coalesced into four about which the entire study was pivoted. These objectives were: acquisition of factual information in science, the understanding of the principles of science, the understanding and use of the scientific method, and the acquisition of scientific attitudes.

Specifically, the present study had four purposes: (1) to describe the current practices in the teaching of biology and chemistry and to describe the persons who teach these subjects in terms of preparation, experience, teaching load, teaching objectives, and professional activities; (2) to determine the relative contributions of factual information, understanding of principles, scientific attitudes, and intelligence, to the understanding of the scientific method; (3) to determine which pupil factors or factors in the pupils' background contribute to the achievement of the objectives of science instruction; and (4) to determine which teacher factors or factors in the teaching situation contribute to the achievement of the objectives of science instruction.

SELECTION OF THE SAMPLE

A review of the literature revealed many studies treating one or more aspects of the problem under consideration in the present study. No one study was similar in problem or scope to the present one. The chief weaknesses in the past studies were the use of matching techniques now obsolete and failure to obtain a truly representative sampling for purposes of statistical treatment. Therefore, the present study placed particular emphasis on securing a sample of schools that might be truly representative. The 483 high schools in Minnesota were stratified into the following categories: schools located in (1) centers under 5,000 people (420 high schools), (2) centers of 5,000 people or more (38 high schools), and (3) the three big cities (25 high schools). The use of stratified sampling with selection of schools within each stratum by use of random numbers, insured that each school had an equal and independent chance of being chosen. All schools chosen by random selection did participate in the study with a few exceptions in the larger-sized towns. The final sample drawn contained 56 schools offer-

* Based on the author's dissertation for the degree of Doctor of Philosophy, University of Minnesota. Major Adviser Professor P. O. Johnson. Paper presented at the New York City meeting of The National Association for Research in Science Teaching, February 15, 1949.

ing both biology and chemistry. The total number of pupils involved in the biology portion of the study was 1,980 and the total number of pupils involved in the chemistry portion of the study was 1,352. Each school or teacher contributed in full as regards the tests and schedules. The following information was obtained: (1) examination scores of each pupil on the pre-test, plus information from each pupil as to sex, age, science courses taken, and college plans; (2) intelligence test scores for each pupil by administering the "Otis Quick-Scoring Mental Ability Test, Gamma Test: Form AM"; (3) completed schedules from each of the teachers; and (4) final examination scores for each pupil on the State Board Examinations developed by the writer.

THE TEACHER SCHEDULE

The analysis of the teacher schedules revealed that the status of science instruction in biology and chemistry in the Minnesota high schools during the year 1946–47 was far from ideal. The results showed the areas where improvement is sorely needed. Good administration and more funds could remedy the problem of too many preparations, too many pupil contacts per day, and too little time and equipment for laboratory work in these sciences. Better training in colleges and universities and inservice training of teachers in the field could remedy in part the lack of preparation in the sciences, the dependence on textbooks and manuals, the lack of understanding as regards the scientific method in science, the dearth of activities such as clubs and field trips, the only moderate use of visual aids, lack of procedures for developing the understanding of principles and acquisition of scientific attitudes, the lack of differentiation in terms of curricular materials, and the lack of professionalism. The 1946 teacher was a younger teacher in terms of experience and a less highly specialized but more comprehensively trained one in terms of science preparation in college as compared with [illegible] science teacher in 1923 and in 1936. This conclusion must be tempered by the fact that the representativeness of the sample in former studies can be questioned.

In addition to the description of the current practices in the teaching of biology and chemistry, the teacher schedule was chiefly designed to furnish quantified data that might be used as a basis for comparing two groups of pupils as to mean achievement as measured by the final examination, holding pre-test and intelligence test scores constant. An example of one such comparison made, was the mean achievement of pupils receiving 74 hours of chemistry laboratory work per year (upper one-fourth of the distribution) as contrasted to the mean achievement of pupils receiving 35 hours of chemistry laboratory work per year (lower one-fourth of the distribution).

THE EXAMINATIONS

One of the problems in the present study was the construction of examinations in biology and chemistry that might be found valid and reliable. Extreme care was taken to insure that the examinations measured what they purported to measure, and did so consistently. The use of external criteria such as elements of the scientific method, lists of biological and chemical principles, statements of scientific attitudes, and use of item analysis techniques, aided in the establishment of valid items. The factors of constant and variable errors and their influence on validity and reliability were kept in mind. The validity and reliability correlations indicated that the tests apparently were efficient in these respects.

RESULTS OF THE STATISTICAL ANALYSIS

Histograms of the part test distributions and total test distributions coupled with descriptive measures such as kurtosis and skewness indicated that the part and total distributions were unimodal and exhibited only a slight departure from normality. It was shown that a slight departure from normality does not lower the efficiency appreciably, and that no serious error for

slight departure from normality was introduced in the significance levels used with the d and f tests.

The intercorrelations of the parts of each examination with each other revealed that the ability to understand and apply the scientific method in biological situations was accompanied chiefly by the abilities to acquire facts and principles, and that the ability to understand and apply the scientific method in chemical situations was accompanied chiefly by the ability to acquire facts. The intercorrelations for both subjects showed that the ability to acquire scientific attitudes as measured in these examinations was not highly related to the other abilities or to intellectual ability as measured.

The multiple correlations indicated that 53 per cent of the variance in the measures of scientific method had been accounted for in biology and that 64 per cent of the variance had been accounted for in chemistry. The percentage of influence of each of the factors as revealed by the squares of the "within" regression coefficients indicated that in both biology and chemistry, intellectual ability contributed the most to the understanding and use of the scientific method, and that of the remaining variables, factual information in chemistry and understanding of principles in biology contributed most to the understanding and application of the scientific method.

Fourteen comparisons were made in biology and 15 comparisons were made in chemistry. Tables I, II, III, and IV show the results of these comparisons. The comparisons were made on the basis of the end scores, holding intelligence and pre-test knowledge constant, using the technique of analysis of variance and covariance. Whenever it was not possible to use the above technique, the d test of Behrens and Fisher was used. Wherever possible the upper one-fourth of the distribution was compared with the lower one-fourth of the distribution for any one comparison. The number of schools in each group was further reduced by one-fourth and the schools in the reduced sample were chosen by random means. In the comparisons where the upper one-fourth could not be compared with the lower one-fourth, the proportion of schools as they occurred in the original population in any one comparison was reduced by one-fourth. The schools chosen for the reduced sample were chosen by random means. The schools chosen for each group in any one comparison were tested for homogeneity of variances and means. Some schools had to be eliminated from their respective groups in order to meet the assumptions basic to pooling. The two or three groups to be compared were tested for homogeneity of variance and regression. If the groups met the assumption of homogeneity of "within" regression coefficients the technique of covariance was applied. If they did not, the d test was used on the end scores only.

The results of the several comparisons indicated that the following factors were not significant in pupil achievement in biology, holding constant scores on the pre-test and intelligence test scores: (1) sex, (2) size of school, (3) number of preparations of the teacher (a teacher having a class in biology, chemistry, history and algebra would have four preparations), (4) quarter-hours of college biology earned by the teacher, (5) the use or non-use of laboratory manuals, (6) the time of laboratory instruction (laboratory instruction preceded, accompanied, or followed class discussion), (7) election of biology, and (8) teacher's knowledge of the scientific method.

The results of the several comparisons revealed that on the average pupils achieved significantly more in biology, holding constant the factors of pre-test knowledge and intelligence, when: (1) the teacher was in the upper one-fourth of the distribution in terms of quarter-hours of college science earned, (2) the teacher had graduated from a private college rather than from a university or teachers college, (3) the teacher had a Master's degree, (4) the number of

TABLE I

BIOLOGY COMPARISONS—ANALYSIS OF VARIANCE AND COVARIANCE—INTELLIGENCE AND PRE-TEST SCORES HELD CONSTANT

	Comparison	D.F.	F	Adjusted Means if F Was Significant		"t" Tests Using Adjusted Means	
I.	Sex	1–761	.87				
II.	Size of school—large, medium, small	2–281	2.60				
III-A.	Number of different preparations—6 *vs.* 1–2	1–169	.82				
III-B.	Biology credits earned by teachers—46 or more *vs.* 16 or less	1–94	.90				
III-C.	Science credits earned by teachers—77 or more *vs.* 32 or less	1–174	8.52**	Upper ¼ Lower ¼	50.19 46.06		
III-E.	Laboratory manual *vs.* no laboratory manual	1–550	.49				
III-F.	Laboratory preceded class discussion *vs.* laboratory followed class discussion	1–320	.17				
III-G.	Elective *vs.* required	1–390	.17				
III-H.	Teachers score on scientific method—8 or more points *vs.* three or less	1–277	.91				
III-I.	Number of laboratory hours—60 or more *vs.* 12 or less	1–205	25.62**	Upper ¼ Lower ¼	55.08 52.34		
III-J.	Undergraduate degree—university *vs.* teachers college *vs.* private college	2–443	79.36**	University Teachers college Private college	48.57 49.57 52.42	Univ.—Teachers coll. Priv. coll.—Univ. Priv. coll.—Tchrs. coll.	.853 4.011** 2.761**
III-K.	Master's degree *vs.* no Master's degree	1–301	10.70**	Master's None	53.49 50.10		
III-L.	Class size—29 or more *vs.* 17 or less	1–169	39.31**	Upper ¼ Lower ¼	50.87 45.79		

* Significant at the 5 per cent level.
** Significant at the 1 per cent level.

TABLE II

BIOLOGY COMPARISONS—USING THE END SCORES ONLY—d TEST

Comparison	d	n_1	n_2	$\sqrt{\text{Ratio of Variances of Means}}$	Means	
III-D. Experience—eight or more years *vs.* one or less years	1.548	156	100	.590	Upper ¼ Lower ¼	54.76 52.07

* Significant at the 5 per cent level
** Significant at the 1 per cent level.

TABLE III

CHEMISTRY COMPARISONS—ANALYSIS OF VARIANCE AND COVARIANCE—INTELLIGENCE AND PRE-TEST SCORES HELD CONSTANT

TABLE III

CHEMISTRY COMPARISONS—ANALYSIS OF VARIANCE AND COVARIANCE—INTELLIGENCE AND PRE-TEST SCORES HELD CONSTANT

	Comparison	D.F.	F	Adjusted Means if F Was Significant		"t" Tests Using Adjusted Means	
I.	Sex	1–344	.11				
II.	Size of school—large—medium—small	2–213	3.38*	Large	47.83	Large—medium	.873
				Medium	46.28	Large—small	2.066*
				Small	43.66	Medium—small	2.103*
III-A-1.	Number of different preparations—6 *vs.* 1–2	1–93	6.35**	6 prep.	47.63		
				1–2 prep.	55.25		
III-A-2.	Number of preparations—6 *vs.* 1–2	1–37	.02				
III-A-3.	Number of preparations—6 *vs.* 1–2	1–102	1.13				
III-B.	Chemistry credits earned by teachers—35 or more *vs.* 13 or less	1–118	8.56**	Upper ¼	48.85		
				Lower ¼	44.35		
III-D.	Experience—ten or more years *vs.* one or less	1–133	4.69*	Upper ¼	45.55		
				Lower ¼	44.35		
III-E.	Laboratory manual *vs.* no laboratory manual	1–214	7.40**	Manual	40.05		
				None	34.54		
III-F.	Laboratory preceded class discussion *vs.* laboratory followed class discussion	1–85	.004				
III-G.	Elective *vs.* required	1–204	7.13**	Elective	41.80		
				Required	34.85		
III-H-2.	Teacher's score on scientific method—9 or more points *vs.* 4 or less	1–136	12.55**	Upper ¼	15.78		
				Lower ¼	12.85		
III-H-1.	Teacher's score of scientific method—9 or more points *vs.* 4 or less	1–148	.06				
III-I.	Number of laboratory hours—74 or more *vs.* 34 or less	1–63	19.71**	Upper ¼	38.13		
				Lower ¼	30.54		
III-J.	Undergraduate degree—university *vs.* teachers college *vs.* private college	2–168	4.87**	Univ.	39.31	Univ.—tchrs.	2.010*
				Tchrs.	35.81	Univ.—priv.	1.286
				Priv.	41.18	Priv.—tchrs.	3.120**
III-K.	Master's degree *vs.* no Master's	1–223	.66				
III-L.	Class size—25 or more *vs.* 16 or less	1–108	19.32**	Upper ¼	42.17		
				Lower ¼	39.89		

* Significant at the 5 per cent level.
** Significant at the 1 per cent level.

TABLE IV

CHEMISTRY COMPARISONS—USING THE END SCORES ONLY—d TEST

	Comparison	d	n_1	n_2	$\sqrt{\text{Ratio of Variances of Means}}$	Means	
I-B.	Educational plans					College-bound	48.75
	College-bound *vs.* terminal	7.778**	309	216	.835	Terminal	40.66
III-C.	Science credits earned by teachers					Upper ¼	50.85
	80 or more *vs.* 40 or less	5.181**	70	43	.770	Lower ¼	38.52

** Significant at the 1 per cent level.
Note: d tests showed that the two groups in I-B and III-C differed significantly as regards pre-test scores and intelligence test scores.

laboratory hours received by the pupils was in the upper one-fourth of the state distribution, and (5) the pupils were in a class the size of which was in the upper one-fourth of the state distribution.

The factor of years of experience teaching biology proved to be non-significant in the achievement of pupils in biology. The test of significance used was the d test, using the end scores only.

The results of the several comparisons indicated that the following factors were not significant in pupil achievement in chemistry, holding constant the factors of pre-test knowledge and intelligence: (1) sex, (2) time of laboratory instruction, and (3) Master's degree.

The results of the several comparisons indicated that on the average pupils achieved significantly more in chemistry, holding constant the factors of pre-test knowledge and intelligence, when: (1) the teacher was in the upper one-fourth of the distribution in terms of quarter-hours of college chemistry earned, (2) the pupils used a laboratory manual, (3) the pupils elected chemistry, (4) the number of laboratory hours received by the pupils was in the upper one-fourth of the state distribution, (5) the teacher had graduated from a university or private college rather than a teachers college, and (6) the pupils were in a class the size of which was in the upper one-fourth of the state distribution.

Several additional comparisons in chemistry were not significant at the 1 per cent level or were not significant at this level in all sub-comparisons when a particular comparison had to be broken up into one or more sub-comparisons. The following tentative conclusions were drawn at the 5 per cent level-of-significance or at the 1 per cent level in one of the sub-comparisons: that on the average, pupils achieved significantly more in chemistry, holding constant the factors of pre-test knowledge and intelligence, when (1) the pupils were in a large-sized school or medium-sized school rather than in a small-sized school (5 per cent level), (2) the teacher had ten or more years of experience teaching chemistry or if the teacher were in the upper one-fourth of the distribution in this category (5 per cent level), (3) the teacher had one or two preparations rather than six preparations per day (1 per cent level in one of three sub-comparisons), and (4) the teacher's knowledge of the scientific method placed her in the upper one-fourth of that distribution (1 per cent level in one of two sub-comparisons).

Two of the comparisons did not lend themselves to treatment by means of the technique of analysis of variance and covariance. Therefore, the d test was applied, using the end scores only. In addition, d tests applied to the pre-test scores and the intelligence test scores, indicated that the groups to be compared were significantly different as regards these two factors. Thus, we were able to draw only the following tentative conclusions, that on the average pupils achieved significantly more in chemistry, when: (1) they planned to go on to college, and (2) the teacher was in the upper one-fourth of the distribution in terms of total quarter-hours of college science earned.

The findings in biology and chemistry were in complete agreement as regards these factors: (1) sex, (2) time of laboratory instruction, (3) number of laboratory hours received per student per year, and (4) class size.

INTERPRETATION OF THE STUDY

The present study did not determine the contributions to achievement in biology and chemistry of such pupil factors as, previous courses taken in science and years of high school mathematics taken. The study did not determine the contribution to achievement in biology and chemistry of such instructional factors as use of the demonstration, field trips and visual aids, and differentiation of instruction. The data are available and other comparisons can be made at a future date.

As was pointed out, two factors were

held constant, namely, pupil intelligence test scores and pre-test scores of the pupil. It might well be that the significance or non-significance obtained in any one comparison might in part be due to the contribution of a factor or factors not controlled. However, every precaution was taken in regard to the fulfillment of randomness as a condition for the tests of significance for the rejection or acceptance of the null hypothesis tested.

IMPLICATIONS OF THE STUDY

The results of the analysis of the teacher schedule indicated that science instruction in Minnesota high schools is in need of improvement. Numerous suggestions were made by the teachers; some of these warrant serious consideration by educators in colleges and universities directly concerned with the preparation of science teachers.

Statistical analysis of the test data revealed those factors which were significant in pupil achievement in science. College instructors, state officers of education, and administrators, can utilize this knowledge in part if not in total in considering problems in science education.

The results of research in science education should be made available to those directly concerned with their utilization to the purpose that boys and girls may be more adequately trained in the sciences, not only for the precise purpose of training future scientists, but with the broader objective of opening new worlds of thought and endeavor to the average citizen of tomorrow. With such purpose in view, the findings and interpretations of this study were sent to each of the teachers cooperating in this study, and to some fifty leading science educators.

EVALUATING ABILITY TO RECOGNIZE DEGREES OF CAUSE AND EFFECT RELATIONSHIPS *

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CAUSE and effect relationships have been previously referred to as causation, causality, and determinism. Aristotle distinguished by name four different kinds of causes: material, formal, efficient, and final causes. With the Renaissance and the growth of natural science, the efficient and final cause were the only ones considered important. Descartes stated that cause and effect are parts of one quality. Hume, Kant, Liebnitz, and Spinoza each proposed different definitions of causality. Philosophers wrangled for years over the proper interpretation to be given to the earlier definitions. The last word on determinism and causation has not been said and agreement on it is far distant. In the latter part of the nineteenth century most students of natural philosophy agreed that cause and effect was a sequence of events.

For the purpose of this discussion, a synthesis of authoritative opinions has been used.

By "ability to recognize the degree of cause and effect relationship" is meant the skill to classify or identify the relationship between two completed physical events as one of the three degrees or levels of causality that are described below.

The term "cause and effect relationship" has appeared frequently in the literature of science education in connection with discussions on scientific attitudes, but in few instances has it been clearly and rigorously defined. For the purpose of this study the

* Paper presented at meeting of the National Association for Research in Science Teaching, New York City, February 14, 1949. Based on thesis submitted in partial fulfillment of requirements for the Ph.D. degree in the School of Education, New York University, 1942.

following definition is adopted: A cause and effect relationship exists between two specific events, if the first always, except for errors of observation, is followed by the second in the same order of sequence. This definition is based on statements by John Dewey,[1] Karl Pearson,[2] William James,[3] Max Planck,[4] A. N. Whitehead,[5] R. H. Stetson,[6] and J. M. Baldwin.[7]

The "degree of cause and effect relationship", also referred to as "level of causality", is determined by the number of events that intervene between a cause and its effect. Degree or level of causality, as presented, is differentiated and recognized in scientific and philosophic literature.[8]

Three levels of causality (direct, indirect, and negative) were employed in constructing the initial and final tests used in the investigation. Direct causality exists when no known event intervenes between a cause and its effect. Indirect causality prevails when one or more connected events intervene between a cause and its effect. Negative causality exists when there is no observable regularity in the direct or indirect sequence of two events.

The study of pupil's understanding of cause and effect relationships has been made by several investigators. Piaget[9] and his assistants conducted tests with individual children and classified the types of causal reasoning that they were capable of doing at certain age-levels. This work was done in Switzerland and the language used was mainly French. Seventeen types of causal relations were found to be prevalent in the thinking of young children. These were grouped, on the basis of the maturity level of the child's reasoning, into three stages.

In the first stage, the child fails to separate his own thoughts and actions from those of the outside world. His explanation of causes contains magical, personal, and moral reasons. For example, "a pebble will cause water-lilies to grow" or "we dream because we have done wrong" or "clouds *must* move because they are alive". In the third stage the more rational forms of reasoning develop. Mechanical, spatial, and logical-deduction types of causes are given. The investigator concludes that no genuinely physical explanation of natural phenomena can be given before the ages of seven or eight years. At the ages of eleven and twelve the third stage of true physical causality comprehension is completed.

Keen[10] made a study of how pupils reason concerning physical and psychological causation. A total of 465 pupils ranging from the sixth to the twelfth grade were questioned in class-room groups by means of multiple choice tests which contained thirteen items on physical problems and seven on psychological ones. Forty-two college sophomores were questioned also. The findings that are relevant to the present investigation were:

1. Considerable sex differences are found in favor of the boys on the physical items.
2. Causal reasoning is not a generalized ability but depends upon specific context of a given problem and upon a long array of specialized abilities.
3. Correlations are relatively low between the scores on the physical items and measures of intelligence.

[1] John Dewey, *Logic: The Theory of Inquiry*, pp. 460–2.
[2] Karl Pearson, *The Grammar of Science*, p. 113.
[3] William James, *The Dilemma of Determinism*, p. 147.
[4] Max Planck, *Where is Science Going?*, p. 123.
[5] A. N. Whitehead, *Process and Reality*, p. 36.
[6] R. H. Stetson, *Dictionary of Philosophy and Psychology*.
[7] J. M. Baldwin, *Dictionary of Philosophy and Psychology*.
[8] H. Levy, *A Philosophy for a Modern Man*, p. 108.
[9] Jean Piaget, *The Child's Conception of Physical Causality*. New York: Harcourt, Brace and Company, 1930.
[10] A. M. Keen, "A Study of the Growth of Concepts and of Reasoning Concerning Physical and Psychological Causation," Doctor of Philosophy Thesis, University of California, 1934.

A research was conducted by Deutche [11] on the development of children's concepts of causal relations. The subjects were 732 pupils from eight to sixteen years of age and in grades three to eight. They were given two tests: one of eleven items based on simple experiments, and one of twelve items based on verbally learned information. The tests were of the essay type and were administered in class-room groups. The results indicate that several levels of development in causal reasoning ability are present in the same individual. No single, saltatory levels of achievement, such as Piaget reported, were observed. Boys made higher scores than girls on both the tests.

Lacey and Dallenbach [12] questioned 160 children whose ages ranged from five to nine years. The oral questioning followed this scheme:

"Would you like to play a game of cause-effect?"

"What is the cause of sleep?"

The pupils were not required to give scientifically accurate answers to show that they understood a cause and effect relationship. Common sense explanations were accepted. The investigators found that children without special instruction learn cause and effect relationships by the end of the eighth or the beginning of the ninth year. Also, the cause and effect relation, when learned, is acquired suddenly.

Oakes [13] investigated the causal explanations of natural phenomena of 151 children of whom seventy-seven were kindergarteners, twenty-four were in the second grade, twenty-four in the fourth and twenty-six in the sixth grade. Seventeen simple experiments and fifteen verbal questions were employed and the children's responses were recorded verbatim. Oakes' findings are in agreement with those of Deutche and Keen but contradict the theory of saltatory or serial growth in children's ability to reason causally which G. Stanley Hall and Jean Piaget supported.

In discussing the relationship between the nature of the problem and the type of the explanation, Oakes states, that, "Rather than there being a typical form of statement, due to the structure of the child mind, and characteristic of a stage in his development, these records indicate that the type of answer depends quite largely both on the child's experience and knowledge and on his vocabulary." [14]

It was found that in explaining experiments which they have seen, children make a higher percentage of cause-and-effect (physical) explanations than they do in response to verbal questions.[15] The investigator hypothesized that, "there is more of a tendency for less bright children to invoke non-materialistic and mysterious causes to account for events in the environment." [16]

The Wisconsin Education Association published an excellent "Cause and Effect Relationship Test in Science".[17] It contained 66 items, each composed of coupled phrases. The first phrase of each couplet is presumably a cause of the phrase that follows. For example, "Heat is applied to water; the water boils". The respondent was asked to choose which one of the four following relationships exists between the parts of the couplet.

(a) The first is practically the sole cause of the second.

(b) The first is one of a number of important contributing causes of the second.

[11] J. M. Deutche, *The Development of Children's Concepts of Causal Relations.* Monograph No. 13, Institute of Child Welfare. University of Minnesota Press, 1937, 104 pp.

[12] J. I. Lacey and K. M. Dallenbach, "Acquisition of Children of the Cause-Effect Relationship," *American Journal of Psychology,* 52 (January, 1939), pp. 103–110.

[13] M. E. Oakes, "Children's Explanations of Natural Phenomena," Doctor of Philosophy Thesis, Teachers College, Columbia University, 1948.

[14] *Ibid.*, p. 49.

[15] *Ibid.*, p. 156.

[16] *Ibid.*, p. 153.

[17] Ira C. Davis, "The Measurement of Scientific Attitude," *Science Education,* 19 (October, 1935), pp. 117–122.

(c) The first contributes only slightly to the second.
(d) The first bears no causal relationship to the second.

The Wisconsin Education Association in 1935 published "A Test for Understanding of the Scientific Method" which was to a great extent a measurement of understanding of causal relationships. The respondent was asked to identify the factors which contributed to the results or effects of an experiment. For example, Problem 4 dealt with "Factors Which Affect the Pitch of a Vibrating String". The factors presented were (a) Length of wire, (b) Tensions, and (c) Weight of Wire per Unit Length. Different conditions were described and the respondent was asked to encircle the factor or factors which contribute to the effect or result.

The Progressive Education Association has had committees working on cause and effect tests at various times. In a *Probable Causes of Events Tests* a series of problems in story form was presented and the respondent was asked to write after each "happening", the probable cause. This test differs from the Wisconsin Education Association's because each question requires the respondent to write a sentence rather than to select one of several prepared answers.

Howard and Robertson [18] constructed an objective scale of thirty-one items for measuring the attitude "conviction of cause and effect relations". The technique of equal appearing intervals similar to that of Thurstone and Chave was employed. Each item stated a causal relationship which the respondent was required to accept or reject. Each item was assigned a statistically determined scale and Q value. The scale value was the median distribution of the item by the judges into nine categories of "understanding of cause and effect relations". The Q value of quartile deviation was one half the scalar distance between the first and third quartiles. The scale has the advantages of being easily administered, it may be determined objectively, and the scores obtained having a statistical significance.

A test to measure "Ability to recognize three different degrees of cause and effect relationships" was constructed by Reiner [19] and used in an investigation in 1941. Each item consisted of a description of a pair of physical events. The sentences describing these events were separated from each other by a // typographic mark. For example, "A cow eats grass. // The cow gives milk." The respondents were asked to state whether the condition described in the first sentence of the above pair was a direct cause, indirect cause, or no cause of the second, by encircling one of the letters D, I, or N, written at the left of the number of each question. The initial test contained sixty items. The final test contained seventy-eight test items (the initial test plus eighteen additional items). The reliability indices of the initial and final tests were .88 and .91, respectively. Each item was selected only if:

1. Seventy-five per cent of a jury of at least six experts agreed upon its syllabus validity, clarity of language, and its answer.
2. It had an internal validity index of above .20.
3. Its difficulty index was between .10 and .90.

Several inherent difficulties are presented in any attempt to evaluate the understanding of causal relationships by means of the ordinary examination. First, how can the examiner know whether a correct response is due to rote memory and/or association rather than to the respondent's correct recognition of a causal

[18] F. T. Howard and M. L. Robertson, "Scaling The Intangibles: A Second Study," *Science Education*, 24 (October, 1940), pp. 249–55.

[19] W. B. Reiner, "The Value of Cause and Effect Analysis in Developing Ability to Recognize Cause and Effect Relationships," *Journal of Experimental Education*, 15 (June, 1947), pp. 324–330.

relationship? Second, to what extent do every day experiences rather than true understandings influence the response given? Third, how many pupils really know the meaning of "cause and effect relationship" and how many attempt to answer a question whose very meaning is not clear to them? Fourth, the science content of the test items must be set at the proper grade and syllabus level and also at a correct difficulty level. This can be determined statistically only after many trial tests have been made. Fifth, the test must have an acceptable internal validity; the high scoring pupils should do well on those items on which the low scoring pupils do poorly. Sixth, is it right to assume that the jury of experts who decide what the correct answer is, will analyze a causal relationship with the same depth of understanding that the respondents will use? In short, how valid are the finally accepted answers and how does this affect the validity of the test?

What is the best scheme or format for measuring various skills in dealing with cause and effect relationships? Is the paired situation, i.e., "A cock crows. // The sun rises.", the best device? What use can be made of having the respondents observe actual situations in a laboratory, lecture, or real life experience instead of only reading about them on an examination paper? How can motion pictures, film strips, slides, and/or still pictures be employed to present causes and effects from which respondents may be asked to draw relationship? Might a more abstract skill be evaluated by presenting data in the form of graphs, tables, and flow sheets and asking that causal relationships be found? There is room for further investigation in the field of evaluation of cause and effect learning.

(To be continued)

CRITICAL SELECTION AND EVALUATION OF ENRICHMENT METHODS IN JUNIOR-HIGH-SCHOOL GENERAL SCIENCE *

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THE PROBLEM AND ITS SIGNIFICANCE

THE purpose of this study was (1) to select certain methods of enrichment suitable for use in the junior high school general science classroom, and (2) to evaluate experimentally these critically selected enrichment methods. An enrichment method was defined as a teaching procedure which served to modify the quality of the pupil's school life in a meaningful way. Method is the mental procedure involved in the learning process. Technique is the manner of attempting to conform to laws involved in a process. Educational devices are direct aids to the processes involved in thinking or aids to the senses. Visual aids are educational devices, not methods. Thus, an enrichment method comprised more than the use of educational devices and techniques. Enrichment was considered as a problem for the normal pupil, not merely for the superior or bright pupil. In other words, it was not intended that an I.Q. of 110, 120, or 130 should decide whether a pupil should be taught by an enrichment method. The determination as to whether a method was to be considered an enrichment method was a problem of the degree to which its use facilitated the

* Based on the author's dissertation for the Ph.D. degree at New York University, *Critical Selection and Evaluation of Enrichment Methods in Junior High School General Science*, 1947. Presented on program of The National Association for Research in Science Teaching, New York City, February 14, 1949.

attainment of certain objectives of science instruction other than the acquisition of additional factual information. Thus, enrichment was a relative rather than an absolute term.

The importance of enrichment lies in the extent that the educational experiences now provided boys and girls are not as meaningful or as educationally significant as they might be.

DELIMITATIONS

This study attempted to evaluate certain critically selected enrichment methods suitable for use in the junior high school general science classroom. All considerations, methods, and conclusions were predicated upon the use of the present syllabus and course of study in junior high school general science for New York City. This study did not attempt to consider (1) enrichment through basic reorganization of the course of study; (2) administrative methods of enrichment involving changes in programming or changes in the regular time schedule; or (3) possible enrichment through use of the integrated or correlated curriculum.

PREVIOUS RESEARCH

Few of the suggestions offered by writers on enrichment methods have been based on the results of research. Most of these suggestions have been prepared for "bright" pupils above a certain I.Q. Prepared enrichment units in social studies were used by Dransfield [1] as additional work to be done by selected pupils at odd times. Hollingworth [2] reported on special enrichment units developed at the Speyer elementary school by and with pupils whose median I.Q. was 140. Maxwell [3] proposed that junior high school general science courses be centered about a program of cultural natural science based on certain elective natural science themes. Osburn and Rohan [4] suggested special club activities and projects organized to enrich the program for gifted children. Woodring, Oakes, and Brown [5] published a source book of science enrichment materials.

MATERIALS AND SCOPE

A total of three hundred and thirty pupils were involved in the experimental phase of this investigation. All of these pupils were students of ninth-year general science at Wade Junior High School, New York City. The experimental procedure required two semesters. The first semester covered the period from September 1942 to January 1943. The second semester covered the period from September 1943 to January 1944. Four classes of normal pupils taught by the investigator were involved in this research each semester. The achievement of the experimental and of the control groups was measured in terms of (1) scientific attitude by means of the Scale for Determination of Conviction of Basic Cause and Effect Relationships by Howard and Robertson,[6] (2) understanding of the social implications of science by means of a Test of Social Implications of Science devised by the investigator, (3) comprehension and interpretation of scientific problems, experiments, and achievements

[1] J. E. Dransfield, *Administration of Enrichment to Superior Children in the Typical Classroom.* Contributions to Education No. 558 (New York: Teachers College, Bureau of Publications, 1935), p. 107.

[2] L. S. Hollingworth, "An Enrichment Curriculum for Rapid Learners at Public School 500, Speyer School." *Teachers College Record,* 39: 296–306, 1938.

[3] P. A. Maxwell, *Cultural Natural Science for the Junior High School* (Baltimore: Williams and Wilkins Company, 1932).

[4] W. J. Osburn and B. J. Rohan, *Enriching the Curriculum for Gifted Children* (New York: The Macmillan Company, 1931), p. 401.

[5] M. N. Woodring, M. E. Oakes, and H. E. Brown, *Enriched Teaching of Science in the High School,* rev. ed. (New York: Teachers College, Bureau of Publications, 1941), p. 402.

[6] F. T. Howard and M. L. Robertson, "Scaling the Intangibles—A Second Study." *Science Education,* XXIV (October, 1940), pp. 249–255.

by means of the Cooperative Science Test for grades seven, eight, and nine, Form R, 1941, Part III, American Council of Education, published by the Cooperative Test Service, New York, (4) application of principles and reasoning in the application of principles by means of Test 1.34, Part I, Problems I, II, III, IV, and VIII, Application of Principles in Physical Science; and Test 1.33a Part II, Problems I, II, V, VII, and VIII, Application of Principles in Biological Science, by the Progressive Education Association, Evaluation in the Eight Year Study, Chicago, Illinois, 1940. The same forms of these tests were used for initial and for final tests. The reading grades of the pupils involved were determined by use of the Stanford Advanced Reading Test, New York City Edition, published by the World Book Company, Yonkers-on-Hudson, New York. Form D was used for the first semester and Form F for the second semester.

The reliability of these tests was as follows: (1) The estimated coefficient of reliability for the Scientific Attitude Scale was 0.56 ± 0.04 for 164 9B pupils on the initial test with a standard deviation of 0.59. (2) The estimated coefficient of reliability for the Test of Social Implications of Science was 0.77 ± 0.02 for 163 9B pupils with a standard deviation of 2.28 on the initial test. (3) The estimated coefficient of reliability for the Cooperative Test of Comprehension and Interpretation was 0.89 ± 0.01 for 164 pupils with a standard deviation of 3.69 on the initial test. (4) The correlation between essay results and the P.E.A. Test of Application of Principles was found [7] to be about 0.90. (5) The coefficient of reliability of the Stanford Advanced Reading Test was estimated to be 0.92 by the publishers, the World Book Company.

[7] L. E. Raths, "Application of Principles," *Bulletin No. 5*, Progressive Education Association, Evaluation in the Eight Year Study, Evaluation Staff of the Commission on the Relation of School and College (Columbus, Ohio: Ohio State University, December, 1936), p. 4.

SOURCES USED

Various types of sources were used to compile a check list of the different types of enrichment methods mentioned in the literature. These sources included: twenty-four city and state general science courses of study, eleven textbooks on the teaching of science, ten textbooks on methods of teaching, fifty-seven published articles dealing with enrichment methods, four textbooks on curriculum enrichment, twelve research bulletins, and three theses dealing with methods of enrichment.

PROCEDURE

The general steps in the procedure were as follows:

1. A check list of enrichment methods mentioned in the literature was compiled from the sources indicated above.

2. Four criteria were established for the selection of those enrichment methods suitable for use in the junior high school general science classroom by the science teacher.

3. These criteria were evaluated and accepted as valid by the unanimous judgment of a jury of seven experts in science education. These validated criteria were: (1) The method must be capable of application to the junior high school course of study in general science, (2) the method must be capable of application within the regular school hours, (3) the method must be capable of integration with the life and purposes of the school, (4) the method must deepen and extend children's experiences.

4. This check list was then analyzed to select those methods which met the definitions, delimitations, and criteria established for this study. These critically selected enrichment methods appeared to fall into three general categories designated as Method A, Use of differentiated enrichment activities; Method B, Use of the scientific or problem method; and Method C, Attention to the social implications of science.

5. This analysis was then validated by a competent jury of experts who agreed with the placement of materials in each instance.

6. For the first experimental semester, beginning September 1942, four units of work were constructed in which each enrichment method was applied. For this purpose outlines of the three critically selected enrichment methods A, B, and C were constructed. As a standard of comparison, a combination of the textbook recitation and the lecture demonstration method was used for the control method. To assist in the further differentiation of the experimental methods from each other and from the control method, the specific experimental vectors for each method were listed. With the outlines and the specific experimental vectors for each method as guides, lesson plans were constructed for each lesson to be taught. These lesson plans were based on the New York City syllabus and course of study in 9B general science for junior high schools.

7. During the first experimental semester, beginning September 1942, four normal 9B classes were taught according to these prearranged lesson plans. The three experimental groups were taught according to Enrichment Methods A (use of differentiated enrichment activities), B (use of the scientific or problem method), and C (attention to the social implications of science) respectively. The fourth group was taught according to the Control Method. One hundred sixty-six 9B pupils took part in the experiment the first semester.

8. During the second experimental semester, beginning September 1943, a different group of one hundred sixty-four 9B pupils took part in the experiment. For this second semester of the investigation combined enrichment methods were used. Outlines were constructed for each of these three combined enrichment methods: (1) Enrichment Methods A and B, differentiated enrichment activities and use of the scientific or problem method; (2) Enrichment Methods A and C, differentiated enrichment activities and attention to the social implications of science; and (3) Enrichment Methods B and C, use of the problem or scientific method and attention to the social implications of science. The specific experimental vectors for these combined enrichment methods were listed. Lesson plans were then constructed based on the outlines and the specific experimental vectors for each lesson to be taught. The same control method was used the second semester that was used the first semester.

9. During the second semester, beginning September 1943, four normal 9B classes were taught by the investigator using combined enrichment method. The three experimental groups were instructed according to (1) Enrichment Methods A and B combined, (2) Enrichment Methods A and C combined, and (3) Enrichment Methods B and C combined respectively. The fourth group was taught according to the Control Method.

OUTLINES OF THE EXPERIMENTAL METHODS

The next step after the critical selection of the three general methods of enrichment suitable for use in the general science classroom was the construction of an outline for each of the three enrichment methods and for the control method. These outlines served as guides for the construction of lesson plans based on each of these methods. As a standard of comparison, a combination of the textbook-recitation and the lecture-demonstration procedure was used for the control method. The outline for each of the three experimental methods and for the control method included the following six elements: (1) general procedure, (2) approach to lesson, (3) demonstrations, (4) pupil activities, (5) assignments, and (6) materials. The materials included the class textbook, equipment for science demonstrations and experiments, motion pictures, slides, film slides, and charts. These were kept constant for all the experimental groups and for the control group. Following are some sample out-

lines of the experimental and the control methods.

OUTLINES OF EXPERIMENTAL METHODS

Enrichment Method "A"

1. General procedure: Use of differentiated enrichment activities.
2. Approach to lesson: A problem arising from the pupil's immediate needs or interests, for example, How do I see color?
3. Demonstrations: Demonstrations performed by pupils individually or in groups whenever possible. Methods by which pupils may construct their own demonstrations or models are discussed.
4. Pupil activities: Differentiated pupil activities.
   a. Construction: projects, charts, models, and booklets.
   b. Research: using source materials to get information; visiting places to get information.
   c. Group discussion: related to a, b, d, and e.
   d. Creative activities: composing original book reviews and working out plans for projects.
   e. Culminating and organizing: presenting the results of the above activities.
5. Assignments: From a list of suggestions prepared by the teacher, the pupils choose for each unit: construction activities, research activities, creative activities, and culminating activities.
6. Materials: Motion pictures, slides, filmslides, charts, and equipment for science experiments. Class textbook: Life and Energy by Morris Meister, Ninth Year, Second Half.

Enrichment Method "B"

1. General procedure: Use of the scientific method.
2. Approach to lesson: A problem arising from some practical life situation, e.g., What causes the rainbow?
3. Demonstrations: Every demonstration is an experiment performed to solve a problem. Scientific controls and safeguards to scientific thinking are used throughout.
4. Pupil activity: Defining the problem, collecting information bearing on the solution to the problem, learning what evidence is, interpreting the evidence, proposing and testing hypotheses in the solution of problems, drawing conclusions and making generalizations, applying principles to new situations which are close to the pupil's life experiences.
5. Assignments: Pupils solve problems arising in the course of the lesson. Pupils solve prepared problems related to the lesson and assigned by the teacher.
6. Materials: The same as for method "A."

Enrichment Method "C"

1. General procedure: Attention to the social implications of science.
2. Approach to lesson: A problem of wide social significance arising from current events, e.g., How has refrigeration improved the quality and variety of foods available today in large cities?
3. Demonstrations: The demonstrations are here used to bring out basic principles of science, and to indicate the social implications and consequences arising from the use of these scientific devices. Thus, the effects of science on our lives are studied.
4. Pupil activity: Utilizing the news of the day as a continual source of information and discussion in science, bringing in advertisements of products offered for sale and analyzing them, reading about the history of current problems in science, studying the contributions of scientists to the solution of social problems.
5. Assignments: Pupils show how the scientific device or scientific principle has affected our lives. Pupils indi-

cate the social significance of the topic or problem.

6. Materials: The same as for method "A."

Control Method

1. General procedure: Use of textbook-recitation and lecture-demonstration.
2. Approach to lesson: A science "story" from the pupil's textbook. Each chapter begins with such a story. The effect is to raise a problem and motivate the development which follows.
3. Demonstrations: Demonstrations are performed by the teacher to illustrate ideas or processes.
4. Pupil activity: Preparing textbook assignments, oral discussion of demonstrations, getting the thought from the textbook, summarizing information.
5. Assignments: Summarizing information learned from the lesson, explaining terms and statements, preparing answers to questions in the textbook.
6. Materials: The same as for the experimental methods.

UNITS USED

During each experimental semester, four units of the regular 9B General Science Course of Study for New York City were taught: Unit 5, Weather; Unit 6, Reproduction; Unit 7, Astronomy; and Unit 8, Bacteria. All of the instruction was carried on by the investigator during the regularly scheduled forty minute science periods. Each class had five science periods per week. During each of the experimental semesters, each of the experimental and each of the control groups was taught for the same number of science periods for each unit of instruction. The scheduling of classes for the different enrichment methods and for the control method was arbitrarily decided upon before the classes had met and without regard to previous training or fitness of the particular class for any particular method.

For the second semester, the type of assignment question for enrichment method B was changed to give the pupils more specific training in determining cause and effect relations. Instead of asking, "Why is it easier for aviators to fly across the Atlantic Ocean from North America to Europe than from Europe to North America?" the pupils were asked, "State with reasons whether you agree, disagree, or cannot decide on the following: It is easier to fly from Europe to North America than to fly from North America to Europe."

PART II

THE EXPERIMENTAL EVALUATION

The experimental evaluation was carried on for two semesters beginning September 1942 and ending January 1944. For the first semester the three experimental groups were taught by the activity method, the problem or scientific method, and the social implications method, respectively. For the second experimental semester, beginning September 1943, the three experimental groups were taught by the activity and the problem methods combined, the activity and the social implications methods combined, and the problem and social implications method combined. During each semester a combination of the lecture-demonstration and the textbook-recitation methods was used as the control procedure. One hundred and sixty-six pupils in four different 9B classes taught by the investigator were involved during the semester beginning September 1942. One hundred sixty-four pupils in four different 9B classes taught by the investigator were involved during the semester beginning September 1943. Thus, a total of three hundred and thirty pupils took part in the investigation. In each semester three experimental groups and one control group was used. Pupil growth was evaluated by initial and final tests of (a) the scientific attitude of cause and effect relationships; (b) understanding the social implications of science; (c) comprehension and

interpretation of scientific problems, experiments, and achievements; (d) application of principles of science; and (e) reasoning in the application of principles.

EQUATING THE GROUPS

All the classes involved consisted of normal progress pupils. They constituted the middle portion in intelligence of the entire grade. The groups were thus roughly equated to begin with. This equation was refined by the following technique. Twenty pupils from each of the experimental and the control groups were equated on the basis of mean reading grade, initial test mean, standard deviation on the initial test scores, and sex. Separate groups of twenty pupils were separately equated for each of the initial tests used. It was decided that the mean reading grade for each group could be considered equated when the maximum difference between the mean reading grade of any experimental group and the mean reading grade of the control group was no greater than 0.3 grade. The dispersion of each experimental group was considered equated to the dispersion of the control group when the maximum difference between the standard deviations of the groups divided by the standard error of the difference in the standard deviations was not greater than 0.52, that is, if the critical ratio $D/6D_6$ was no greater than 0.52. This meant that the chances were less than 70 in 100 that the true difference between the standard deviation of the experimental group and the standard deviation of the control group was greater than zero.[8] The same procedure was followed for equating the three experimental groups and the control group during the second experimental semester as was used during the first experimental semester.

CONTROL OF NONEXPERIMENTAL FACTORS

To minimize the effect of certain factors other than the experimental factors the following precautions were taken:

1. To secure equivalent groups the experimental and the control classes were equated on the basis of reading grade, number of pupils, sex, initial test mean in the dependent variable, and the standard deviation in the dependent variable. The experimental and the control classes were equated separately for each test.

2. The same instructional materials, such as filmslides, slides, charts, textbooks, and apparatus were used for all groups.

3. Teacher skill, personality traits, and teacher zeal were controlled since all the experimental and the control groups were taught by the investigator.

4. The time devoted to learning activity was carefully considered. All the instruction was carried on by the investigator during the regularly scheduled science periods. During each of the experimental semesters, each of the experimental and each of the control groups was taught for the same number of science periods for each unit of instruction. A record of pupil attendance was kept.

5. To secure adequate delimitation of the experimental vectors, the experimental vectors were listed for each enrichment method and for the control method. All the lesson plans were constructed within this framework. Separate daily lesson plans were constructed for each lesson that was taught. These lesson plans were carefully adhered to.

6. The scheduling of classes for the different experimental methods and for the control method was arbitrarily decided upon before the classes had met and without regard to previous training or fitness of the particular class for any particular method.

RESULTS

The experimental evaluation of the critically selected enrichment methods is here presented in terms of those phases of pupil growth measured by the tests of scientific attitude, social implications of science, comprehension and interpretation, application

[8] H. E. Garrett, *Statistics in Psychology and Education*. New York: Longmans, Green and Company, 1939, p. 213.

of principles of science, and reasoning in application of principles. The criterion of a significant difference was D/6D=3.00 or virtual certainty.[9]

Sample tables are presented to show the evaluation of pupil growth as measured by the tests of scientific attitude and of understanding of the social implications of science. See Tables I, II, III, and IV.

mine cause and effect relationships than did the control group. The problem group showed the greatest growth but in no case was the difference between the control group and the experimental group statistically significant.

B. Combined experimental factors. See Table III. All the experimental groups showed greater growth in ability to distinguish cause and effect relations than did the control group. Those groups in which the problem method was used exhibited statistically significant gains over the control group.

TABLE I

FIRST SEMESTER—SCIENTIFIC ATTITUDES

Raw Scores on the Howard, Robertson Scale of Cause and Effect Relations Obtained by Four Equated Groups * of Twenty Pupils Using Single Experimental Factors

Class	Method	Number of Pupils B+G=T	Pupils' Reading Grade	Initial Status			Final Status			
				Mean	S.D.	D/6D6	Mean	Diff.†	S.D.	D/6D
9B1	Activity (A)	11+9=20	10.4	5.40	0.49	0.09	5.70	0.24	0.62	1.20
9B3	Problem (B)	11+9=20	10.4	5.40	0.49	0.09	5.72	0.26	0.55	1.37
9B4	Social Implications (C)	11+9=20	10.1	5.40	0.46	0.18	5.61	0.15	0.36	0.94
9B5	Control	11+9=20	10.2	5.40	0.48	—	5.46	—	0.60	—

* These groups were initially equated on the basis of reading grade on the Stanford Advanced Reading Test, Form D; sex; initial test score on the Robertson, Howard Scale of Cause and Effect Relations; and Standard Deviation=S.D.

† Diff. means difference between the final mean of the experimental method and the final mean of the control method.

TABLE II

FIRST SEMESTER—SOCIAL IMPLICATIONS

Raw Scores on the Investigator's Test of Social Implications of Science Obtained by Four Equated Groups * of Twenty Pupils Using Single Experimental Factors

Class	Method	Number of Pupils B+G=T	Pupils' Reading Grade	Initial Status			Final Status			
				Mean	S.D.	D/6D6	Mean	Diff.†	S.D.	D/6D
9B1	Activity (A)	10+10=20	10.5	18.3	1.90	0.05	21.4	1.8	1.64	3.05
9B3	Problem (B)	10+10=20	10.5	18.3	1.92	0.00	20.6	1.1	1.05	2.18
9B4	Social Implications (C)	10+10=20	10.3	18.3	1.95	0.07	21.9	2.4	1.45	4.29
9B5	Control	10+10=20	10.2	18.3	1.92	—	19.5	—	1.95	—

* These groups were initially equated on the basis of reading grade on the Stanford Advanced Reading Test, Form D; sex; initial test score on the investigator's Test of Social Implications of Science; and Standard Deviation=S.D.

† Diff. means difference between the final mean of the experimental method and the final mean of the control method.

I. Scientific attitude

A. Single experimental factors. See Table I. All the experimental groups showed greater growth in ability to deter-

[9] *Loc. cit.*

TABLE III

SECOND SEMESTER—SCIENTIFIC ATTITUDES

Raw Scores on the Howard, Robertson Scale of Cause and Effect Relations Obtained by Four Equated Groups* of Twenty Pupils Using Combined Experimental Factors

Class	Method	Number of Pupils B+G=T	Pupils' Reading Grade	Initial Status			Final Status			
				Mean	S.D.	D/6D6	Mean	Diff.†	S.D.	D/6D
9B1	Activity+Problem (A+B)	10+10=20	10.4	5.25	0.48	0.45	5.75	0.49	0.47	3.77
9B4	Activity+Social Implications (A+C)	10+10=20	10.2	5.25	0.44	0.10	5.57	0.31	0.40	2.87
9B5	Problem+Social Implications (B+C)	10+10=20	10.2	5.25	0.43	0.00	5.80	0.64	0.42	4.50
9B6	Control	10+10=20	10.2	5.25	0.43	—	5.26	—	0.32	—

* These groups were initially equated on the basis of reading grade on the Stanford Advanced Reading Test, Form F; sex; initial test score on the Robertson, Howard Scale of Cause and Effect Relations; and Standard Deviation=S.D.

† Diff. means difference between the final mean of the experimental method and the final mean of the control method.

TABLE IV

SECOND SEMESTER—SOCIAL IMPLICATIONS

Raw Scores on the Investigator's Test of Social Implications of Science Obtained by Four Equated Groups* of Twenty Pupils Using Combined Experimental Factors

Class	Method	Number of Pupils B+G=T	Pupils' Reading Grade	Initial Status			Final Status			
				Mean	S.D.	D/6D6	Mean	Diff.†	S.D.	D/6D
9B1	Activity+Problem (A+B)	10+10=20	10.1	17.8	2.16	0.10	18.8	0.4	2.05	0.66
9B4	Activity+Social Implications (A+C)	10+10=20	10.1	17.8	2.16	0.10	22.8	4.4	1.36	8.80
9B5	Problem+Social Implications (B+C)	10+10=20	10.1	17.8	2.11	0.00	21.0	2.6	2.57	3.66
9B6	Control	10+10=20	10.3	17.8	2.11	—	18.4	—	1.70	—

* These groups were initially equated on the basis of reading grade on the Stanford Advanced Reading Test, Form F; sex; initial test score on the investigator's Test of Social Implications of Science; and Standard Deviation=S.D.

† Diff. means difference between the final mean of the experimental method and the final mean of the control method.

II. Social implications

A. Single experimental factors. See Table II. All the experimental groups showed greater growth in understanding social implications of science than did the control group. The group that received the special training in recognizing social implications of science showed the greatest growth.

B. Combined experimental factors. See Table IV. All the experimental groups grew more in understanding social implications of science than did the control group. The two groups that received special training in recognizing the social implications of science showed the greatest growth. These gains were statistically significant.

III. Comprehension and interpretation

A. Single experimental factors. All

the experimental groups showed greater growth in comprehension and interpretation of scientific problems, experiments, and achievements than did the control group. The gains of the activity group and of the social implications group were statistically significant.

B. Combined experimental factors. Due to an error in timing the tests, results could only be obtained for two experimental groups. Neither of these experimental groups achieved significant growth in comprehension and interpretation as compared with the control group.

IV. Application of principles

A. Single experimental factors. The activity group and the social implications group showed greater growth in ability to apply scientific principles than did the control group. The social implications group was the only group that showed statistically significant gains over the control group. The growth of the problem group was the same as the growth of the control group.

B. Combined experimental factors. All the experimental groups using combined experimental factors achieved greater growth in ability to apply scientific principles than did the control group, but none of these gains was statistically significant.

V. Reasoning in application of principles

A. Single experimental factors. Although all the experimental groups grew more in ability to reason in applying scientific principles than did the control group, the only statistically significant gains were made by the social implications group.

B. Combined experimental factors. All the experimental groups showed greater growth in ability to reason in application of principles than did the control group, but none of these gains was statistically significant. The most potent combination was the problem and the social implications methods.

CONCLUSIONS

The following conclusions were drawn:

1. Three general methods of enrichment suitable for use in the junior high school general science classroom were found which met the definitions, delimitations, and criteria established for this study. These methods were: (a) Use of differentiated enrichment activities, designated the Activity Method; (b) use of the scientific method, designated the Problem Method; and (c) attention to the social implications of science, designated the Social Implications Method.

2. The Problem group, the Activity group, and the Social Implications group showed greater growth in ability to determine cause and effect relationships than did the Control group. The Problem group showed the greatest growth. These differences in favor of the experimental methods were not statistically significant. When combined experimental methods were used, those groups in which the Problem Method was used exhibited statistically significant gains over the Control group. In this use of combined experimental methods, the original problem procedure was modified to give the pupils more specific training in determining cause and effect relations.

3. The Problem Method was superior to the Control Method in training pupils to understand the social implications of science, and in improving comprehension and interpretation of scientific problems, experiments, and achievements. These differences in favor of the Problem Method were not statistically significant. In respect to growth in ability to apply principles of science and in ability to reason in the application of principles, the Problem Method had no significant advantages over the Control Method.

4. Special training in understanding the social implications of science resulted in statistically significant differences in growth in favor of the experimental group over the control group in understanding the social implications of science; comprehension and interpretation of scientific problems, experiments, and achievements; application

of scientific principles; and reasoning in the application of principles.

5. In respect to growth in understanding cause and effect relations, the Social Implications Method was superior to the Control Method, but inferior to the Activity Method or to the Problem Method. This difference in favor of the Social Implications Method was not statistically significant. When combined with other methods, the Social Implications Method produced statistically significant gains only with respect to understanding social implications of science.

6. The Activity group was significantly superior to the Control group in respect to growth in comprehension and interpretation of scientific problems, experiments, and achievements and in growth in understanding the social implications of science.

7. The Activity group grew more than the Control group in understanding cause and effect relationships, in application of scientific principles and in ability to reason in application of principles, but these differences in favor of the Activity group were not statistically significant.

POSSIBLE IMPLICATIONS

It appears that the ability to carry on the many kinds of activities employed in the study of science is specific rather than general.

1. The outcomes of a course of instruction in general science are definitely related to the methods of instruction employed.

2. General training in scientific attitudes through use of the problem solving method of procedure does not result in statistically significant differences in pupil growth in understanding cause and effect relationships as compared with the lecture demonstration procedure unless the pupils are given specific training in determining cause and effect relationships.

3. Use of differentiated pupil activities in science produces significant understanding by pupils of the social implications of science, but the best way to ensure such understanding is by specific instruction along those lines.

4. If pupils are expected to grow significantly in ability to apply principles of science and to reason in the application of these principles, the pupils must be given specific instruction in these respects.

5. The type of reasoning involved in problem solving procedure is not the same as the reasoning employed in the application of scientific principles.

RECOMMENDATIONS

Certain recommendations for educational procedure may be based on the findings of this study.

1. One criterion for the selection of the content of science should be that the content deal with those developments of science that have important social significance.

2. Science instruction should be more closely integrated with the social studies, but the responsibility for teaching the social implications and effects of scientific discoveries should rest upon the science teacher.[10]

3. If significant pupil growth toward certain objectives of science instruction is desired, the instruction must be specifically directed toward these ends. Specific teaching procedures should be employed to achieve certain specific outcomes. Meticulous use of the scientific method by the teacher may not produce in the pupils significant growth in conviction of cause and effect relationships. Growth in this scientific attitude may be furthered by giving the pupils specific instruction in determining cause and effect relationships.

[10] R. K. Watkins, "Who Is Responsible for the Social Implications of Scientific Discoveries?" *The Science Teacher*, Yearbook Supplement (American Council of Science Teachers, 1942), pp. 4, 27, 28.

THE SCIENTIST IN THE MAKING: SOME DATA AND IMPLICATIONS FROM THE JUNIOR SCIENTISTS ASSEMBLY *

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AT THE close of the last war, in the midst of a period of revolutionary technological and scientific advancement, America was suddenly confronted with critical shortages of scientific manpower. Though the cause was obvious, the problem served to call attention to the broader concerns of professional training and science education which have had the attention of the American Association for the Advancement of Science for some time. This Association, the parent body of American scientists, has, in the past decade, been increasingly active in considering problems of science in relation to society and specifically to education.

In October, 1946, on the motion of Otis W. Caldwell, a staunch proponent of science education programs, the Executive Committee of the A.A.A.S. appointed a Committee on the Junior Scientists Assembly. The Committee [1] under Dr. Morris Meister's Chairmanship, represented major areas of science teaching: the public and private schools, the science clubs, junior academies of science, and the colleges. It hoped to focus attention of scientists and science teachers on the education of those young people who planned to become professional scientists. A series of meetings were projected, geared to bring about a fresh exchange of ideas among secondary and college teachers and their present and former science students.

It was the Committee's immediate decision to hold its first meeting in conjunction with the A.A.A.S. at Boston, during Christmas week of 1946. In preparation for this, the Committee set up a plan which has since become the pattern for the annual meeting of the Junior Scientists Assembly. A group of young scientists-in-training residing or attending college in the region of the meeting are invited to participate at the Assembly where the audience consists of other science-interested young people, science teachers, and scientists. The participants get to know one another in one or two preliminary meetings. At the Assembly they give reports of research and carry on a panel discussion (in which the audience joins) on important issues related to science and science education.

The responsibility of extending invitations fell on the Committee members, who in turn called on other teachers of science and on the local director of the Assembly. Those invited were young people recommended as being interested in science and actively preparing for a scientific future. Some had been outstanding in their high school careers; some were active in science clubs and junior academies of science; some were winners of science contests. The Committee tried especially to get women to participate and even tried to discover if everyone invited would be willing and able to contribute freely in an open forum before a large audience.

Each person invited to participate in the Junior Scientists Assembly filled out a brief questionnaire giving some pertinent facts regarding their interest and activities in science. This information was used as a basis for program notes and was also a help in selecting the panel participants and speakers. From these single sheets of data came most of the facts to be reported here.

It is hardly necessary to point out that the Junior Scientists Assembly was not set up for purposes of research. Neither were the questionnaires research instruments.

* Paper presented at the New York City meeting of the National Association for Research in Science Teaching, February 14, 1949.

[1] Morris Meister, Mary Creager, John C. Hogg, Hugh C. Muldoon, John W. Thomson, Jr., J. J. Ward, Herbert S. Zim, Margaret P. Patterson and Keith Johnson.

Hence, the uncontrolled situation had to be accepted as it existed, with limitations which will be apparent in the data presented.

In three years, 69 young men and women invited to participate in the Junior Scientists Assembly filled out the questionnaire. Practically all attended the meetings. The group consisted of 58 men and 11 women as follows:

	Men	Women	Total
1946	26	2	28
1947	16	3	19
1948	16	6	22
Total	58	11	69

Because the three meetings were held in the East (Boston, Chicago and Washington, D. C.) those invited were from these sections. No special effort was made to secure an even geographic distribution, yet 17 states and the District of Columbia were represented. The participants came from 47 different towns and cities. The larger cities and their suburbs played a major, though not a dominating role in this distribution.

The function of the Junior Scientists Assembly is to bring together young scientists in the midst of their professional training. This point is not arbitrarily defined. In fact, a reasonable range of age and experience is desired. The age and educational status of the group studied indicates it was kept within realistic limits.

AGE AT TIME OF MEETING

Age	Men	Women
16	2	—
17	10	—
18	19	2
19	6	3
20	6	1
21	5	—
22	5	3
23	4	2
24	1	—
Number	58	11
Average age	19.1	20.5

Educational status at the time of the meeting reflected the position of the participants even more. Sixty-eight per cent were college undergraduates. Nineteen per cent were in graduate schools. The few who were employed had completed their undergraduate training and were getting practical working experience, while or before continuing their studies. The high school seniors all had unusual records of activity and interest in science and were continuing their science programs in college.

EDUCATIONAL STATUS AT TIME OF MEETING

	Men	Women
High school seniors	4	—
College undergraduates	42	5
Graduate schools	9	4
Working	3	2
Total	58	11

The first thing about these potential scientists that strikes home is the fact that their interest in science has been a long one. The evidence that science interest or talent has deep, penetrating roots is gaining wide recognition in science education. The question "At what age did you first become interested in science?" brought responses which ranged from the ages of 5 to 15—none over that. In addition, 12 participants indicated that they had become interested in science at a very early age. They used such phrases as "very young", or "as early as I can remember". Lacking numerical indication these could not be combined with the other data. But if pressed, these participants would probably recall ages within the range and about the average of the others.

AGE OF FIRST INTEREST IN SCIENCE

Age	1946	1947	1948	Total
5	—	—	1	1
6	1	1	—	2
7	—	2	1	3
8	2	1	2	5
9	2	1	2	5
10	8	4	2	14
11	5	1	1	7
12	2	4	2	8
13	1	1	1	3
14	1	—	3	4
15	2	—	1	3
Very young	2	4	6	12
Don't know	2	—	—	2
Total	28	19	22	69
Averages	10.7	9.9	10.7	10.5

Ten and a half years is the average age at which the 69 participants became interested in science. This is figured conservatively. When the age was recalled as a two-year period, the higher age was taken, i.e., 9–10 was recorded as 10 years. The agreement between these figures and similar data obtained from 104 participants in the American Institute Science Fair, held in New York in 1937 is remarkable.[2] Then the age of first interest in science averaged 10.6, with a range of from 5 to 18 years. However, only one individual of the 104 became interested at 15; none at 16 or 17; and only one at 18. Thirty per cent of the boys became interested in science before the age of 10; 61 per cent between the ages of 10 and 12 and only 9 per cent after that age.

If the age of first becoming interested in science was a matter of vague recall, it might well be dismissed. However, this date tends to mark the beginning of appropriate, functional participation in science activities. Each participant presented an abridged, chronological statement of these activities. It is evident from this listing that interest in science—even at the age of 10 or less—is something dynamic. Reporting this functional pattern is difficult, unless one uses case history techniques, science autobiographies, and the like. An example from one paper will give some indication of the kind of pattern that develops from the time a youngster first becomes interested in science. This is a statement of a 21-year old graduate student in physical chemistry who became interested in science "about 8 at the latest."

> At first, I was quite interested in nature and wanted to study to become a naturalist. I collected articles about natural history and collected insects. After that I became interested in electricity and radio, carrying out simple home experiments and building radios. At various times, I was also interested in mineralogy, collecting specimens of rocks and minerals. I became interested in microscopy trying to culture paramecia. About this time, I became interested in chemistry, accumulating some apparatus and chemicals. This grew to appreciable dimensions. All this time I was reading various books relating to the particular science interesting me at the moment and also scientific books on other subjects. . . . I had no place [to work at home]. We lived in an apartment. However, when we moved to a house, I appropriated a corner of the basement, 8 feet square. This now contains a lab bench and several bookcases full of chemicals and apparatus.

Apropos of this young man's comments, a number of participants reported as part of the brief record of their activities, their extensive reading of scientific books. As their science interests took shape, these students turned to popular volumes, college

[2] Zim, Herbert S., *Science Interests and Activities of Adolescents,* Ethical Culture Schools, New York, 1940, pp. 142–143.

AREAS OF FIRST SCIENCE INTEREST

	Men	Women
Biology and nature study	4	2
Animal life (birds, aquaria, protozoa, insects)	3.2	1
Medicine and first aid	4.5	1
Physics, mechanics, airplanes	3.2	—
Electricity and radio, motors	5.8	—
Chemistry, chemistry sets	14.8	—
Geology, rocks and minerals	1.3	1.3
Astronomy	5.2	1.3
Natural phenomena; "everything"	4	—
General and elementary science courses; school laboratory work	9	3
No answer: "don't know"	1	1
Miscellaneous:		
Photography	0.5	—
Mathematics	0.5	—
Meteorology	—	0.3
Scientific method	1	—
	2	0.3
Total	58	11

textbooks and adult references as part of their voluntary reading. One important phase of the early interest in science is the acquisition of a rich store of pertinent information through reading, experimentation, and observation.

Without attempting an analysis of the early activities in which the participants engaged prior to their attendance at the meetings, there is evidence here and elsewhere [3] that a period of differentiated intellectual growth began at about the time the science interest was clearly recognized. The questionnaire furthermore asked the participants "What interested you then?", i.e., at the time of first interest. The responses indicate quite a range of interests (fractions indicate two or three interests reported). Some were unfortunately listed in vague terms or according to school subject and hence do not give as clear a picture as others.

Chemistry appears as an important early interest of science-minded young people. It is often the first area of science in which the individual can "experiment" and get first-hand experience and personal success. The values of this type of satisfying contact with science materials cannot be overestimated.

Another indication that the early interest in science expressed by the participants is a functional one, is the fact that about 67 per cent of them had developed a home laboratory of some kind or some place where they could experiment. These amateur laboratories were in basements (most popular place), kitchens, bathrooms, attics, and bedrooms. They were used for chemical, biological, radio, and astronomical work. Some who did not have laboratories made it quite clear in their replies that this was not due to a lack of interest on their part. The only participant who clearly indicated that a laboratory meant little to him was a budding mathematician who said *NO* emphatically and added pointedly, "A mathematician needs only a sheaf of paper and a writing instrument."

Boys are more apt to build laboratories than girls, and do spend more time in them. Previous studies have indicated that such laboratories occupy much of the free time and absorb nearly all of the spending money of the individuals who make them.

Moving up-to-date with the participants gives us an opportunity to look at their present interests and areas of study in science. The fact that the group was mainly undergraduate may account for the considerable number of split choices. Perhaps these indicate that final professional plans have not yet jelled. But in all the cases where two and sometimes three areas of interest are expressed, they are all closely related. A frequent division of interest involves mathematics and some other science, usually physics.

Though too limited for detailed analysis, the data above indicate areas of interest which are parallel to those shown in pre-

[3] Zim, *ibid.*, pp. 151–212.

PRESENT AREA OF INTEREST AND STUDY

	Men	Women
Chemistry (general, industrial and organic)	7.7	0.3
Biochemistry	4.5	2
Biology (zoology, bird study, forestry)	3.3	2.3
Medicine (medical research, neurological research)	9	2
Anthropology, physical	—	1
Pharmacological research	0.5	—
Engineering (general, electrical, chemical, mechanical)	13	—
Physics (general, nuclear, theoretical, electronics)	11	1
Astronomy	1.5	2
Science	1.5	—
Mathematics	5.2	0.3
Non-science (economics and music)	0.8	—
Total	58	11

vious studies. Teachers of science have long been aware of the differences between boys' and girls' expressed interests in science. These differences seem rooted in our cultural conception of masculine and feminine roles. The forces that shape them are apparent in the toys an infant receives and in the child's daily experiences of living. When the men's major interests center in physics and engineering and the women's in biological sciences, we have another expression of the same cultural determinants. Most of these interests in biological sciences pattern around the medical area. Interest in atomic energy is expressed through physics rather than through chemistry.

The expressions of present interest in science on the same sheet as expressions of first interest, and age of first interest, create an unusual opportunity to determine how long these interests of would-be scientists persist. Again, the data are of the "straws in the wind" variety, because of the sample size and because of such unknown factors as the influence on recall when asking present and early interests in the same questionnaire. There is reasonable indication from more detailed case histories that the data from this group are typical.

When the participant listed a specific early interest in science, a specific present interest and the age at which he or she first became interested, it was easy to determine the facts. The present and first interest were identical for 21 men and 3 women—36 per cent and 27 per cent respectively. The present and first interests were related, i.e., in the same broad areas of science for 17 men and 2 women—29 per cent and 18 per cent. In total, about 65 per cent of the men and 45 per cent of the women were active in a field of science identical or similar to that of their first interest. Only 4 men and 2 women had a present interest in an entirely different area of science. For the rest the data were insufficient to pass judgment—usually because the early interest was expressed in general terms as "nature study" or "general science." It is probable that further data from this group would increase the percentage of those with identical or related interests.

For those whose first and present interests were identical, the persistence of the interest as obtained by subtracting the age of first becoming interested in science from age at time of the meeting. These reported interests persisted from 3 to 13 years—a very considerable period, considering the

PERSISTENCE OF SCIENCE INTEREST

(Based on present science interest and interest at time of first becoming interested in science.)

Persistence:		Men	Women
Identical or nearly so			
Examples:	chemistry set: industrial chemistry first aid: medicine electricity: physics	21	3
Related (in same areas of science)			
Examples:	chemistry: physics medicine: colloidal chemistry astronomy: chemistry	17	2
Different areas of science			
Examples:	ants: physics geology: obstetrics chemistry: forestry	4	2
Insufficient data to judge			
Examples:	nature study: physical chemistry general science: biology "everything": mechanical engineering	16	4
	Total	58	11

average age of the participants. Men's identical interest persisted (on the average) 7.5 years; women's, 10 years. The details are given below:

PERSISTENCE OF IDENTICAL SCIENCE INTERESTS
(From age at answering questionnaire minus age of first interest in science)

Years	Men	Women
3	1	—
4	1	—
5	2	—
6	2	—
7	5	1
8	3	—
9	2	—
10	3	1
11	2	—
12	—	—
13	—	1
Total	21	3
Average	7.5	10.0

That these young people who participated in the Junior Scientists Assembly will be scientists is almost certain. Their expression of interest and the record of their activities is supplemented by answers to two questions concerning their future—questions about their immediate and ultimate goals. Immediate goals, as would be expected, are expressed largely in terms of the completion of formal education—courses and degrees. Some expressed their immediate goals in somewhat broader terms involving education, research, or preparation for life work. But both groups clearly strive toward completing their preparation for active work in science.

Ultimate goals, though harder for the participants to envision in some cases, were also strongly centered in professional areas of science. Personal happiness and fulfillment rose sharply in ultimate goals in contrast to immediate goals. Strong intellectual or scholarly aims penetrated the vocational expressions. Subordinate to the expression of ultimate vocational goals was the fact that some stated or implied that this might take them into positions of administrative or applied science as opposed to research. A larger number of participants specifically mentioned teaching as (or part of) their vocational goal. Some clearly implied that teaching was a necessary evil which one interested in certain fields of research had to endure, if he wanted to eat.

IMMEDIATE GOALS

	Men	Women
Completion of course or degree	32.5	4.5
Education in broader terms	11.5	2
Specific preparation for or participation in research	3.5	2.5
Preparation or success in job, position or interneship	9	2
Broader relations of science to life *	1	—
Personal happiness and success	0.5	—
Total	58	11

* To see if modern mathematics has any meaning in life and society.

It is hardly necessary to call teachers' attention to the fact that these talented young people present a challenge to science education. Their early and persistent interest in science indicates that our concern with developing professional scientists must extend down through the junior high school into the upper elementary grades. This does not and should not mean the extension of vocational education or the segregating of pupils with strong science interests. It does imply teacher awareness and the creating of opportunities for such pupils to work, achieve success and broaden their perspective and use of tool subjects. The place to recognize and aid science talent should not be limited to the senior high school. Effective education for those who will be the scientists of tomorrow depends upon continual effort right through the schools from the primary grades up.

This has been a rather superficial look at a group of young men and women on the verge of entering scientific careers. Yet it reminds us that the function of science in general education is not completed unless

ULTIMATE GOALS

Goals	Men	Women	Total
No answer	2	0	2
"Don't know"	2	0	2
Personal fulfillment of life, marriage, etc. (often with some indication of social usefulness)	6.5	0.5	7
Increase of science or knowledge in general	4.5	1	5.5
Vocational (predominantly a specific career in science or area of research. Sometimes study leading to such a career or research)	43	9.5	52.5
Of these only 6.5 stated or implied clearly that their vocations might be in business or administration or that research might not necessarily play a part in it.			
Of these, 11 specifically mentioned teaching of some science as their goal or part of their goal.			
Totals	58	11	69

it also meets the needs of students going into the scientific professions as well as those who, as laymen, may use science in their daily living. The training of scientists demands a broad, solid, educational basis. It is a task involving the soundest kind of general education since language arts, mathematics and other tool subjects are of prime importance, as is a social viewpoint, an understanding of peoples and of democracy.

Schools have given some attention to talented students—but largely in a hit or miss fashion. The science teacher usually takes the initiative in offering help. Clubs and other extra-curricular activities are also valuable. Yet, schools cannot often keep up or match the activities of the interested youngster who builds his own basement laboratory and goes ahead with his own experiments. It is somewhat ironical that science education, which has been so active in promoting the role of science in the continuous growth of the child, has often been negligent of the most talented pupils.

Two problems emerge from consideration of the facts about young scientists and from discussing their problems with them. The early origin of science interests—usually before or about the time of their first contact with science in school—indicates that teachers in the upper elementary and junior high school grades can give the greatest initial help to these pupils. With this help, senior-high-school science teachers will be in an even more favorable position than now in furthering science talent.

The classroom teacher in the elementary grades, no specialist in science at all, may be of real assistance by recognizing science interest and providing opportunity for its expression in relation to other class activities. If we are to take advantage of the interests which exist and many more which can arise and develop into powerful educational drives, more and better opportunities for science are needed on the elementary and junior-high-school levels.

The other problem comes much closer to the Junior Scientists Assembly itself and helps explain why the meetings, panels and informal discussions have been so appreciated by the participants. Many have said that the experience was far more valuable than any courses they had taken.

During his senior year in high school and the undergraduate years that follow, the young scientist grows increasingly aware of the "facts of life" in science. He or she becomes acutely cognizant of jobs, salaries, favored institutions, discriminations in regard to sex and race, and the strong economic and intellectual competition in some areas of science. There is also the conflict between the desire for a normal social life and the unrelenting grind which may characterize advanced scientific studies. All of this may arouse doubts and fears about the individual's ability to "make the grade."

This state of affairs may be further complicated by the fact that these talented young men and women, while still students, have already participated in research or have engaged in advanced studies. They have some claim to being within the scientific professions though still in student status. The need for making that transition—at least in part—is a poignant one. The transition is a powerful morale builder and has other very practical values too. The meetings of the Junior Scientists Assembly, because of their conjunction with the meetings of the A.A.A.S., provide a unique opportunity for the introduction of potential scientists to their professions.

The invitation to attend the Junior Scientists Assembly is the first that most participants have received to attend a scientific meeting. The arrangements which have been worked out often make this attendance possible at low cost. At the Assembly the opportunity to meet and discuss a wide range of problems with people the same age from other colleges is eagerly seized. Since the topic for panel discussion is chosen to bring in many divergent ideas, this too helps to make the experience a broadening one. But perhaps even more important is the opportunity for participants to attend the general and sectional meetings of the A.A.A.S. Here they see in person the men who are the authors of textbooks and leaders in important fields of research. The young people seek out sectional meetings closest to their fields of interest and participate in discussion with scientific decorum and maturity. Through these meetings and the informal discussions that punctuate them, the young scientist finds himself accepted into a group where his continued participation through the years is a good possibility.

The kind of initiation into professional life which the meetings, exhibits and discussions of the annual A.A.A.S. meeting provide are of intrinsic educational value. The Junior Scientists Assembly helps make this possible as part of its function. An important contribution of the Junior Scientists Assembly so far has been to highlight this problem and to point out the values of increasing the role which might be played by an organization like the A.A.A.S. in the development and training of our future scientists.

Finally, it would be unfair to imply that the Junior Scientists Assembly is a one-way proposition. The stimulus, uplift and ideas too, that science teachers and scientists get from meeting with these energetic newcomers is something of real value. Teachers and scientists who have attended the sessions have made this very clear. The suggestions of the participants often coincide with the best thinking of the teachers. The criticisms of science education which are voiced are those which teachers recognize as being fair and deserving.

It is clear that these meetings of the Junior Scientists Assembly and the other A.A.A.S. sessions can be of great value to scientists-in-training. At the same time, it can help mature scientists become aware of the young people who are going to follow in their footsteps and who will benefit by their cooperation. A further study [4] and evaluation of the participants, their interests, talents and abilities, may help in refining our own concept of science talent and in finding better ways to effectively use it in schools, colleges and in the laboratory.

[4] At the time this is going to press, information sheets are being received from those going to the fourth Junior Scientists Assembly in New York. The data supplied are in close agreement with those previously collected and indicate the same patterns of interest and activity in science.

SCIENCE TEACHERS' OBJECTIVES AND ATTITUDES TOWARD USING COMMUNITY RESOURCES: A STUDY OF FIFTEEN MARYLAND NEGRO SECONDARY SCHOOLS *

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PURPOSE OF THIS STUDY

THE purpose of this study was to investigate science teachers' objectives and attitudes toward using community resources and data in teaching. It was believed that the study would direct science teachers to self-evaluation and would result in improved teaching practices. Moreover, its findings supply data which are of value to the State of Maryland and Morgan State College officials in charting new directions in science education.

PROCEDURE FOLLOWED

Preliminary forms were prepared and discussed with officials in both the Baltimore and State Department of Education. On the basis of these conferences, a set of tentative schedules were prepared. These were submitted to a doctoral committee, and to a research group on science teaching, Teachers College, Columbia University. On the basis of these responses, the scope of the study was limited to three aspects of science teaching: A. Purposes, B. Teacher Information, and C. Availability, Use, and Value of Community Resources in Teaching.

Three schedules covering the above were revised and submitted to a jury of experts. Three Baltimore high schools and a comprehensive county high school were visited to check the adaptability of the forms to the study. The results of these analyses were incorporated into the three proposed final schedules and submitted to the doctoral committee, and to the Executive Officer of the Advanced School. Covering letters to principals and to science teachers were also submitted. From these responses, the final schedules and two covering letters were prepared. These were mailed to all science teachers and principals in the Negro secondary schools of Maryland.

All of the Baltimore schools included in the study and a few county schools were visited.

The replies received from Schedules A and C, visits to schools, conferences, and study of source materials formed the basis of this paper.

SCIENCE TEACHERS' OBJECTIVES

The study of science teachers' objectives was based on the results of the analyses of Schedule A, Purposes. Teachers were requested to evaluate by checking in one of four columns the purposes underlying the junior and senior high schools of Maryland and of science education according to their degree of importance. These columns were headed as follows: of most importance, of average importance, of least importance, and unimportant. If the purpose did not exist in the school, from which the answer was given, teachers were requested to check column five.

The schedule included three additional columns which were headed as follows: achieved, achieved in part, not achieved as yet. Teachers were requested to evaluate by checking in one of these columns the degree to which the purposes had been achieved. Thus each statement of purpose had eight columns, four indicating degrees of importance, one indicating that the purpose did not exist in the school, and three indicating degrees of achievement.

These statements of purposes were

* Paper presented at the New York City meeting of the National Association for Research in Science Teaching, February 14, 1949. Based on author's unpublished doctoral study at Teachers College, Columbia University, *Science Teachers' Objectives and Attitudes Toward Using Community Resources in Teaching.*

divided into four groups: junior high, senior high, science education, and science objectives of the high school. Most of the statements were derived from four sources.[1] A few additional statements of purposes were included in each of the four divisions of the schedule to evaluate emphases on subject matter *per se*, and to guard against the possibility of teachers checking continuously in one or two columns. Some of the statements were judged to be in opposition to the real purposes of the school. For example, a statement in the junior high list—to develop mastery of the content of subjects—is such a statement.

In a summary of the study on purposes, the investigation indicated that these teachers had been caught in the wave of a program of revision and reorganization. The old foundations have been shaken and these teachers are moving progressively in the direction of "newer" science teaching programs. This "newer" program is yet in the process of evolution, and its directions are still being charted. Considerable progress has been made. Much remains to be done.

The teachers are facing real teaching and learning situations with the Negro youth of Maryland. These situations are being increasingly centered in personal and community problems. Both the physical and biological resources of the community have been used in developing functional purposes. These purposes have been developed by providing the kinds of learning and experience that ramify into such areas of human activity as health, safety, citizenship, democratic living, social adjustment, personality, and good taste.

THE TEACHERS CONCEIVE OF PURPOSES AS DIRECTIONS OF GROWTH

On the junior-high-school level, all of the respondents considered the purpose centered in the development of actual living practices which promote personal and community health and safety and an understanding of the scientific basis of such practice—an objective of most importance. There is an apparent need for a more thoughtful consideration of the purpose connected with the development of an introduction to the modern world of applied science and its value for adaptation to and control of the environment. One-third of these teachers considered it a purpose of average importance. Data from such sources as the National Association of Secondary School Principals indicate that such a purpose is rooted in one of the imperative needs of youth.

All of the senior-high-school teachers considered the purpose—to develop an understanding of the place of science in modern life and practice in sound scientific thinking—a most important one. This is one of the imperative needs of youth. It also received recognition in "A Report of the President's Commission on Higher Education." While the latter report is addressed primarily to workers in institutions of higher education, it is none the less true that it has relevance for high school education. It is the task of these teachers to provide the kinds of learning and experience that will enable pupils to participate more effectively in such functional areas as: conservation, leisure-time science, science for vocational orientation, and science for consumer buying. While considerable progress has been made in these areas, the need is there for increased emphasis and concentration on the role science teaching can play in these vital aspects of living. The available evidence revealed that these teachers need to concentrate more fully on the importance of the physical environment.

Teacher evaluation of the importance of the purposes of high school science are shown in Figure 1. It is apparent that increased supervisory, teaching, and in-service concentration should be placed on the development of purpose *d*.

[1] Fraser, Thomas P. *Science Teachers' Objectives and Attitudes Toward Using Community Resources in Teaching.* Unpublished doctoral thesis, Teachers College, Columbia University, 1948.

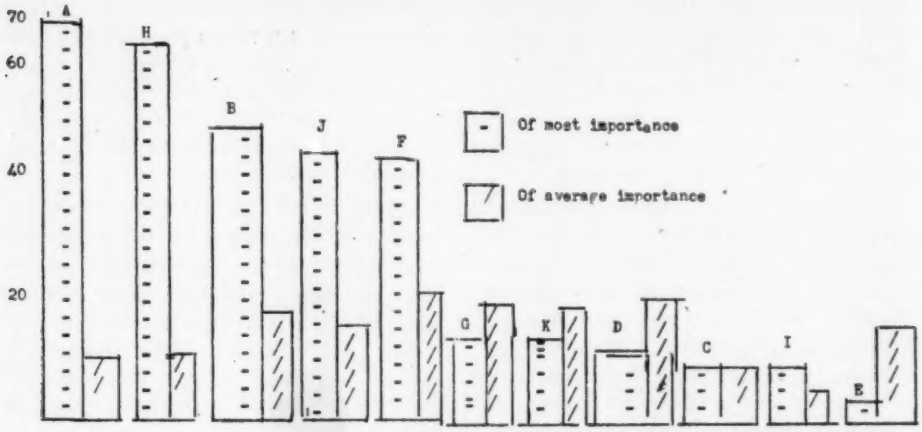

FIGURE I

TEACHER EVALUATIONS OF IMPORTANCE OF PURPOSES OF HIGH SCHOOL SCIENCE

A. An understanding of the relations among things observed.
H. Better understanding of scientific method, recognition of the possibilities of widespread application of this method and confidence in their own ability to apply scientific method to practical problems.
B. A coherent picture of the world.
J. Increased freedom from fear and guilt, and from the influence of false and fraudulent claims whether it be commercial or political.
F. A clearer comprehension of some of the effects of infiltration of ideas gained from the study of science upon current interpretations of the nature of the world and of man, and of human betterment.
G. A mastery of the facts associated with the organization of the physical universe and its change through time.
K. Ability to remember many specific facts on the organization of the living world and its changes through time.
D. An understanding of the application of science through technology.
C. A mastery of the molecular theory.
I. A mass of detailed knowledge on the solar system and the universe.
E. A technical interpretation of the atomic theory.

There was considerable lack of emphasis on the mastery of facts *per se* as one moves from a consideration of the responses to the general objectives of science education to a study of the specific objectives of high school science. Study of the former table indicated that the purpose centered in developing an acquaintance with the facts and principles of the biological and physical sciences was being achieved by 30 per cent of these teachers. While there is no attempt here to decry facts, it is nevertheless true that what is actually needed in this regard is the main scientific facts concerning the nature of the world and man.

Personal and community health, and the attitudes, appreciations, and understandings involved in the scientific method received high evaluations.

Science laboratories need to be placed on a functional basis. To put it another way, they need to provide opportunities for real problem solving.

The available evidence indicated that science departments were in harmony with the purposes of the school and that they were of help in attaining these purposes.

AVAILABILITY, USE, AND VALUE OF COMMUNITY RESOURCES IN TEACHING

Schedule C of the study was captioned "Availability, Use, and Value of Community Resources in Teaching."

Teachers were asked to indicate by

checking yes or no whether or not the kinds of community resources or data included in the schedule were available and used in their science teaching. They were also asked to indicate by checking, what value was attached to each kind of resources or data regardless of whether or not it was employed in their teaching. This latter consideration was based on checking one of three columns: valuable, not valuable, and uncertain as to value. A page of the schedule was also devoted to the teacher's activities in the community.

HUMAN RESOURCES

The tables of this section of Schedule C presented data in terms of composition of the population, births, deaths, accidents, illness, health facilities, impairments, social maladjustments, institutional cases, dependent, indigent, educational records, educational level of the people, family situations, organizations for human needs and welfare, and recreational, library, and museum services.

Separate tabulations were made for Baltimore and county teachers and summaries are presented on this basis.

Baltimore

In summarizing the section concerned with the human resources of the community, it may be said that certain functional aspects of science teaching were indicated. Moreover, teachers were centering learning experiences in a variety of resources not commonly associated with traditional science teaching. Such resources as the following were being used by Baltimore teachers: delinquency, school attendance, health, absences, retardations, failures, number and sex of births, vandalism, special classes, schools, parks and recreation, hospitals, drop outs, garbage disposal, water supply services, communicable disease services, school medical services, food and milk control, sanitary inspection, dental services, vital statistics, general medical services, school services through museums, health records, local health officers, opportunities for forums and hobbies; kinds, location, hours of museum exhibits.

Baltimore teachers attached greatest value to the areas connected with the following: health, delinquency, absences, retardations, failures, behavior problems, health records, parks and recreation, hospitals, vandalism, school attendance, special classes, schools, drop outs, welfare, garbage disposal, water supply services, communicable disease services, opportunities for forums and hobbies; location, equipment, hours, books, periodicals and newspapers in the library; school services through the museum, school medical services, food and milk control, vital statistics, hospitalization, general medical services, playgrounds and parks, social and civic recreation programs; kinds, location, hours, publications and exhibits of the museums; dental services, sanitary inspection, organized athletics, and number and types of schools.

County

The leading resources used by county teachers were: school attendance, health, home or hospital care at births; number, cause, and other (especially in the home) accidents; delinquency, absences, behavior problems, health records, nationality and racial groups, marital and occupational status, cause of illness, retardations, failures, special classes, drop outs, working papers, anecdotal records, courts, parks and recreation, school medical services, garbage disposal, water supply services, local health officers, food and milk control, communicable disease services, hospitalization, dance halls and theaters, sanitary inspection, vital statistics, general medical services, finance of health department, and dental services.

The leading items that were considered valuable in science teaching among county teachers were: health, school attendance, cause of illness, behavior problems, health records, anecdotal records, police, schools, parks and recreation, cause of accidents,

absences, retardations, failures, hospitals, home or hospital care at birth, criminal and delinquent, delinquency, special classes, drop outs, working papers, welfare, courts, institutions, water supply services, school medical services, garbage disposal, local health officer, finance of health department, number of illiterates, dance halls and theaters, hospitalization, general medical services, number of children of school age, number and types of schools, percentage in attendance in schools, playgrounds and parks, organized athletics, social and civic recreational programs, opportunities for forums and hobbies, pre-natal service, infant welfare service, dental service, food and milk control, provision for attendance worker, enrollment in public school, and organization and administration of the schools.

Comparisons of these items reflected some significant differences between Baltimore and county teachers. Delinquency data (social maladjustment) received higher percentages of responses on usefulness as an item among Baltimore teachers than among county teachers.

Juvenile delinquency is usually associated with urban areas, and it was to be expected that Baltimore teachers were using these data to a larger extent than did the county teachers. This leading item of usefulness points up the social role of science teaching. How can science teachers aid in the reduction of this form of human waste? How can they aid in preventing it? How can they assist in providing more adequately for the needs and requirements of youth during these critical years of maturation and social adjustment? It seems that this is an important aspect of human growth and development.

Rather significant differences may also be noted in connection with the data on births. Home or hospital care received larger percentages of responses among county teachers than among the Baltimore group. Number of births received higher percentages of responses for Baltimore than for county teachers. Sex of births received higher percentages of responses among Baltimore than among county teachers. The item on home or hospital care should challenge county teachers to a greater extent of usefulness than Baltimore teachers. Hospital facilities are lacking in some of the rural communities. There is still an acute problem of reducing infant mortality, especially at birth and in the period immediately following birth. Infant mortality is much higher among Negroes than among the white group. It is higher in the Maryland counties than in Baltimore.

The acuteness of the hospital problem was reflected also in a study of the Table centered in "Organizations for Human Needs and Welfare." The item on hospitals in that table showed that larger percentages of Baltimore than county teachers were using these data.

Perhaps one of the most striking revelations in this study was that the data centered in cause of death was not used by higher percentages of teachers on all levels. The comparatively low usage of the data by Baltimore teachers may be because these teachers are specialized in their teaching. Even on the junior-high-school level, a teacher was interviewed who taught only the units of astronomy, air, and water. This teacher commented that the schedule was filled out with these units in mind. Some of the senior-high-school teachers teach only chemistry or physics. It is difficult to explain the low usage of the data by county teachers.

THE FOOD, CLOTHING, AND HOUSING CONDITIONS OF THE COMMUNITY

The items of the Tables on this section of Schedule C indicated that they represented data and resources which could be used to raise the level of living in the communities in which these teachers were employed. Food, clothing, housing and health comprise the broad categories of the Project in Applied Economics, sponsored

by the American Association of Colleges for Teacher Education. The experiments conducted by cooperating schools in this project showed specific instances in which schools had been used to improve the food, clothing, shelter and health conditions of a community.

County

The highest percentages of these teachers were using data and/or facilities on housing as follows: fire and safety hazards; provisions for comfort and health; sanitary conditions; need for beautification; and need for the control of termites, other insects, and rats.

These same facilities and/or data were considered valuable by the highest percentages of county teachers. They indicated, however, that such housing data as number who rent their homes, and conditions of the homes were of equal importance and value. County teachers also regarded such food items as the following of equal importance and value: number of farms, concern for inspection and examination of food handlers, and family budgets. The only overall high ranking clothing item was stores.

Baltimore

The highest percentages of Baltimore teachers indicated that they were using the housing data and/or facilities as follows: need for beautification; need for control of termites, other insects, and rats; heating and insulation; and provisions for comfort and health.

High rankings were accorded the following items: sanitary conditions, need for beautification, and fire and safety hazards. The concern of the people of the community for conservation was regarded as the highest ranking item of value on food.

Responses to the section dealing with the manner in which science teaching may be used to improve the level of living in the communities in which these teachers were employed showed specific instances in which learning experiences were centered in projects designed to achieve this result.

Since health is a functional aspect of science teaching, and an area referred to in the Project in Applied Economics, it seemed appropriate to call attention to its contribution as viewed in the Table on Health Facilities. Garbage disposal, water supply services, communicable disease services, school medical services, food and milk control, sanitary inspection, dental services, vital statistics, hospitalization services, local health officers, general medical services, and finance of health department represented the facilities and data most extensively used by these science teachers. Moreover, the highest percentages of them considered these facilities and data valuable in science instruction.

THE NATURAL SETTING OF THE COMMUNITY

The Tables of this section of Schedule C showed the extent to which science teachers used resources and data connected with the physical factors and biological resources of communities. They also reflect the values attached to these resources and data. The summaries for both county and Baltimore teachers are presented below.

County

County teachers in general were using more of the data and resources connected with physical factors than biological resources. Except for zoological and botanical gardens, the items comprising the biological resources of the community are within the environment of most of the county schools. Supervisory emphasis should be placed on this aspect of science teaching. The values county teachers attached to physical resources were higher than for biological resources. This difference is not noticed on the Baltimore level. The items on usefulness and on value in both tables received roughly the same percentages of responses.

Baltimore

Some of the elements of the physical environment, like range of temperature,

topography, mineral resources, influence of environment, and location and natural resources, are used extensively in science teaching by Baltimore respondents. In addition, the biological resources show widespread usage. Teachers assigned relatively high values to these teaching resources.

INDUSTRIAL RESOURCES OF THE COMMUNITY

The Tables centered in these resources indicated the responses of science teachers to the items on transportation, communication, industrial, and business facilities of communities.

County

In summarizing these data, it may be said that a majority of county teachers were using teaching resources centered in transportation, communication, and vocational orientation. Such community facilities as the following were also used: telegraph, telephone, railroad lines, electric and bus lines, postal service, radio, water transportation, and the facilities and/or data centered in the opportunities for making a living. It was interesting to note that the social role of these facilities and/or data were being developed in connection with communication. The responses indicated that such topics as the following were used: newspaper and press policies; use of press, radio, and other facilities for good will; and possibility of increase or decrease of communication for the benefit of the people.

County teachers considered the facilities and data mentioned above valuable in planning science instruction. It was interesting to note that the data associated with opportunities for making a living was among the highest ranking items of value when the total situation for all tables on the county level were studied. The two high ranking responses on value that did not appear in the paragraph above were air transportation and number of natural resource firms.

Baltimore

Baltimore teachers were using the same facilities and/or data mentioned in connection with the county teachers. Communications, however, was the leading area of instruction. Learning experiences were centered chiefly in the radio, telephone, and telegraph.

Large percentages of Baltimore teachers assigned highest ratings on value to the facilities specified in communication, and indicated that such social interpretations as the following would be helpful: uses of the press, radio, and other facilities for mutual good will; and newspaper and press policies. Data and/or facilities centered in the area of opportunities for making a living received one of the highest overall ratings on value.

LOCAL HISTORY, GOVERNMENT AND RELIGIOUS PREFERENCES OF THE COMMUNITY

This section was devoted to an appraisal of the responses to specific items connected with the local history, government, and religious preferences of communities.

County

When the overall ratings were compared, it was apparent that the highest percentages of county teachers were using the following data and resources connected with the local history of the community: historical events, persons; settlement, early government; first settlers; and origin and development.

The highest percentages of these teachers declared that these data and resources were valuable in science teaching. Significantly, they added two items as follows: public utilities and the attitude of the church toward health. The latter item was contained in the table on the local government and religious preferences of the community.

Baltimore

The highest percentages of Baltimore teachers were using data and resources connected with the local government of the community as follows: provisions for public utilities, extensiveness of fire and other protection, and provisions for health and sanitation.

The highest percentages of these teachers

declared that these resources were of value in science instruction. Significantly they added: liberal attitude toward races, and the program of the community for social uplift, from the table on the local government and religious perferences of the community.

The highest percentages of county teachers were centering learning experiences in the data and resources connected with the local history of the community. The highest percentage of Baltimore teachers were centering learning experiences in the data and resources connected with the local government of the community.

THE TEACHER'S ACTIVITIES IN THE COMMUNITY

The study attempts in this division of the schedule to probe for evidences that tend to indicate that (1) teachers were using community trips to build up a better knowledge and understanding of the community; (2) the extent to which school communities called upon science teachers for assistance; and (3) additional ways in which teachers work with agencies in the community.

Teachers used a number of places in building a better understanding and knowledge of communities. Trips to railroad terminals, botanical gardens, zoological gardens, weather bureaus, blast furnaces, electric plants, farms, lumber mills, water supply, and public health service stations represented some of the places used by these teachers.

A substantial proportion of these teachers work with and in the churches. In fact, church work is the leading community activity among both groups of teachers. Other agencies with which these teachers work are Boy Scouts, Parent-Teachers Association, interracial committees, National Association for the Advancement of Colored People, Girl Scouts, Urban League, Red Cross, local teachers association, and civic organizations.

These teachers rendered a variety of services to these community groups. Some of the services rendered were: speeches, securing speakers, teaching golf, training singing groups, playing a violin solo, organizing and sponsoring clubs, preparing radio script, taking leadership in community movements, participating in drives, holding membership in community groups, holding membership in national groups through local community chapters, demonstrating science applications, singing, teaching Sunday School, organizing panels, organizing national movements on local level, organizing campaigns for funds, and working with local teachers associations.

Institutions engaged in teacher education must not only train teachers for effective classroom performance, but also for competent assistance and leadership in community activities.

TEACHER EVALUATION OF SCHEDULES

It was postulated that this study would direct science teachers to self-evaluation. To check this, two overall questions were raised at the end of Schedule C. As put to these teachers, the questions were:

1. Do you believe that teachers who reflect on these schedules will, as a result, improve their teaching practices?
2. Do you feel that the exercise of filling out these schedules has been of value? For example, have you gotten useful suggestions for your work?

The replies to the first question by Baltimore teachers were as follows:

Yes—58.8 per cent.
No—5.9 per cent.
Perhaps—5.9 per cent.
No Response—29.4 per cent.

The answers to the second question as tabulated for Baltimore teachers were as follows:

Yes—58.8 per cent.
No—5.9 per cent.
Useful as a Reminder—5.9 per cent.
No Response—29.4 per cent.

The replies to the first question by county teachers were as follows:

Yes—84.6 per cent.
Not Necessarily—7.7 per cent.
No Responses—7.7 per cent.

The following data show what county teachers thought about the second question:

Yes—84.6 per cent.
Some, But Not to a Large Extent—7.7 per cent.
No Responses—7.7 per cent.

IMPLICATIONS FOR SCIENCE EDUCATION AT MORGAN STATE COLLEGE AND FOR IMPROVEMENT OF SCIENCE TEACHING UNDER PRINCIPALS AND SUPERVISORS

The concluding portion of the study was centered in an attempt to pull together the threads of the entire investigation by answering the questions: What are the essential characteristics of desirable science education at Morgan State College? What are the essential characteristics of in-service education for Baltimore? Maryland?

PATTERNS OF NEEDS GROWING OUT OF STUDY

Needs were identified for developing teaching competence as follows: (a) functional areas of science; (b) non-science areas; (c) scientific method of problem solving; (d) use of teaching materials; (e) use of community resources; (f) adult education; (g) extra-class activities; and (h) intercultural relationships.

The areas in which science teachers need broad understandings are: (a) human growth and development; (b) secondary education, including the place of science in its program; and (c) basic sociological findings with respect to the operation of social groups.

To meet the needs of today's complex society, science teachers need a wide range of knowledge and a broad background of general education.

RELATION OF NEEDS TO MORGAN STATE COLLEGE

The general education curriculum should be redesigned to provide unified and broad background for *all* students. Students should take (a) three surveys or integrated courses in the biological and physical sciences, social sciences, and humanities, and a central seminar integrating the three survey courses; (b) English; and (c) health and physical education. In addition students should take a course in mathematics (or demonstrate competence in mathematical computations in a proficiency examination).

Prospective teachers of science in the junior and senior high schools should take additional work in science, science education, education, psychology, sociology and economics, intercultural relationships, and human growth and development.

All the science teaching at Morgan should inculcate scientific method of problem solving.

The College should exercise leadership in the in-service education of science teachers.

A Source Materials Bureau should be established at Morgan State for use by supervisors, and teachers of science. The materials should be circulated on a loan basis.

The "Division of Natural Science" should take full responsibility for science education with the active cooperation of all departments of the College. Practice teaching should be cooperatively observed. Moreover, students engaged in such activity should live in the community and participate in its activities.

The College should develop a five-year program of teacher education.

RELATION OF NEEDS TO BALTIMORE AND STATE SUPERVISORS AND PRINCIPALS

In-service courses and workshops should be cooperatively planned so as to achieve the understandings, and develop the teaching competences mentioned in Patterns of Needs.

A series of meetings should be planned for the purpose of discussing this report and mapping procedures for the implementation of some of its findings.

A plan for observing the work of master teachers should be encouraged.

Teachers should be encouraged to participate in community activities.

Teachers should be stimulated and encouraged to attend and participate in the

meetings of national educational societies.

Teachers with significant projects should be encouraged to prepare articles for publication.

Teachers should take leadership in planning programs of science education in connection with the meetings of the Maryland Education Association, and Beta Kappa Chi.

Teachers and officials of the Baltimore and State school systems should look increasingly to Morgan State College for leadership, stimulation, encouragement, and assistance.

A NON-VERBAL TEST OF THE ABILITY TO USE THE SCIENTIFIC METHOD AS A PATTERN FOR THINKING *

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THE teacher of science believes that he has a unique function in the educational system. No matter what his subject or at what grade-level he teaches, he feels that one product of his teaching which his students should be able to demonstrate is the ability to solve problems, using the scientific method as a pattern for this activity. He affirms that only in science are there so many opportunities for the application of this process. He includes, of course, a great part of mathematics which involves the solution of problems.

Most science texts and many teachers state that the scientific method is to be taught. Exercises in its application are often provided, and many students gain power in the use of the method; but when proof of definite increments in this power is sought it is not forthcoming. There seem to be few valid and reliable tests suitable for the measurement of the aptitude, or for the measurement of gains in the ability.

The teacher, by observations during students' recitations and laboratory exercises, is able to give good marks to those who exhibit this trait. However, memorization of facts and a knowledge of simple structure, especially as seen in type-problems, often enable a student to perform convincingly, although he is really not able to use the scientific method as a pattern for attack upon *new* problems. Conversely, many students are confused by the facts, the formulas, and the vocabulary, which have come at them so fast that they never have had the chance to demonstrate that they are good thinkers. It is possible that many students with this aptitude never reach high-school science classes.

This is not to say that the abilities to memorize facts, to manipulate figures with facility and to substitute them in formulas, and to learn new vocabularies, are not desirable and necessary. The sum of these abilities is not, however, equal to the ability to use them all in solving problems not only of the classroom but of the environment. The precise definition of the word "talent" will not be attempted here, but this transcending of partial abilities in the use of the scientific method comes close to being a talent in the popular educational sense. This paper is an attempt to explain this point of view, and to describe a test which may be measuring the possession of this talent.

Obviously, a test of the ability to think in the scientific-method pattern should require the testee to go through the steps of the scientific method in order to arrive at the correct solutions of the problems of the test. Failure to apply these steps should result in low scores on the test.

The steps of the scientific method were

* Paper presented at the New York City meeting of the National Association for Research in Science Teaching, February 14, 1949.

crystallized by Keeslar [1] from the opinions of 22 research scientists who evaluated 54 major and minor elements of the method.

1. Sensing a problem and deciding to try to find the answer to it.
2. Defining the problem.
3. Studying the situation for all facts and clues bearing upon the problem.
4. Making the best tentative explanation or hypothesis as to the best possible solution of the problem.
5. Selecting the most likely hypothesis.
*6. Inventing and carefully planning one or more experiments to test the hypothesis, isolating the experimental factor wherever possible by using a control.
*7. Testing the hypothesis by carrying out the experiment with great care and accuracy.
*8. Running check experiments involving the same experimental factor to verify the results secured in the original experiment.
9. Drawing a conclusion.
10. Making inferences based on this conclusion when meeting new situations in which the same factors are operating.

Items six through eight involve the actual procedure of testing a hypothesis by physical means. There is no perfect substitute for this manipulation of realia in the laboratory or in the environment. It is almost impossible below the university level, however, to observe the individual student as he plans and carries out a series of experiments. Also, it is *invention* that is required for final testing of a hypothesis, and this seems to the writer to be beyond the scope of objective group testing, even though it is the most significant of all abilities which demonstrate, in part, this talent for employment of the scientific method of thinking.

If the actual experimentation of items six through eight is not available, it may be that other items in the list will be useful. To paraphrase some of the other seven items:

1. Sensing the problem, which involves observation of materials and events.
2. Defining the problem.
3. Classifying data into pertinent and non-pertinent categories.
4. Setting up an hypothesis or hypotheses.
5. Selecting the most likely hypothesis.
9. Drawing a conclusion.
10. Testing the hypothesis by repeated attempts to fit new materials into its structure.

[1] Oreon Keeslar, "The Elements of Scientific Method," *Science Education*, Vol. 29, No. 5, December, 1945, p. 275.

If these are considered as a group, it may be suggested that here are seven items which are related in one way; they all suggest *discriminatory choices.*

1. Observation is valuable only when it is discriminatory, for haphazard observation does not reveal *classes* of objects or events, does not show structure.
2. The defining of the problem means choosing among several possible problems.
3. Classification is discrimination between or among items.
4. Setting up an hypothesis or hypotheses is what is often called thinking. It is still the choosing of one or more of many possible explanations of the data (or of the classifications to which the data are assigned).
5. When the selection of the most likely hypothesis is made, there comes into play the highest level of human thought. It might be called *critical discrimination.*
6. The final, or better the *current,* choice of a conclusion is a reinforcing process, still selecting and fitting data into the proper classifications, to test them against the chosen hypothesis for "best fit," again the process of critical discrimination.
7. The final critical discrimination is involved in the verification of the validity of the choice of the hypothesis by re-examination of every item classified according to the plan of that chosen hypothesis. In the scientific method *every one* of those items so chosen must fit, and *all other items must not.*

DESCRIPTION OF THE TEST

The Picture-test is a series of sub-tests, related in that they are all aspects of the environment, and that they all pose problems which can be solved through the association of two sets of pictures. There are seven categories; each delineated by four pictures, each of which represents a particular sub-division of the category. (Three more categories of a biological nature have been added.) The categories have to do with electricity, with air pressure, with one phase of chemistry, with mechanics; they are samples of common environmental science.

The four pictures are mounted on a card, and as can be seen in Plate 1, the card is placed in a box. Under each of the four pictures is a small bin. From six to eighteen separate loose pictures may be picked up by the testee, closely examined, sorted, compared, and finally dropped into one of the bins. The only directions are

to "place each picture in the bin where it fits best."

High scores are obtained by those who discover what the four pictures on the card represent. As each card is on a single topic, the task is to discover the more or less fine shades of *dis*-similarity among the four pictures. The loose pictures serve as clues, and as they can be moved around without penalty, once the pattern exhibited by the four pictures on the card is discovered, the way is open for careful comparison and critical discrimination. The whole process is that of the scientific method as a way of thought. It is the unique contribution of the test, and the writer believes that success on the test is a measure of the ability to use the scientific method as a pattern of thinking.

As there are now ten separate areas in all, with pictures (photographs taken by the author) carefully chosen as being objects and situations common to most rural and urban environments from which American high-school students come, there is a high probability that the items are valid. As in making any test, personal judgment and experience are factors in the choice of items. This test is no exception, and a jury of eleven science specialists and science-educated laymen examined the original 133 items. To remain in the test, each item had to meet the approval, in subject-matter and placement under one and only one of the four pictures on the card, of *all* members of the jury. It may be interesting to test-makers to note that this validation accounted for the removal of 63 items, leaving 70 in the final form. A statistical item-analysis removed 27 more items as non-discriminatory, leaving only 43 items which were used in the scoring. The mean of 25.36 indicates there is no need to worry about a low ceiling on the test. Indeed, in over 700 administrations of the test, the highest student mark has been 37, and only two persons, both school administrators, have ever scored perfectly. In general, the test is suitable for grades 7 through 12. Older students seem to read into the pictures meanings which do not appear to the younger testees—a phenomenon known as "extension" to the psychologist. Below grade 7, there are occasional high scores, but as in any test, experience is a factor in recognizing the items. An unusual score was made by a science-interested youngster of seven, who already was making radio transmitters and was doing chemistry experiments. His score was 35.

Data Obtained upon Giving the Test—Information about the test was sought through the Fisher technique [1] of random selection (true random selection, using a table of random numbers to go into a school and pick testees from the whole school roster) and the analysis of variance. Two hundred seventy-one pupils, grades eight through twelve, in nine schools and from five cities and towns, representing a school population of 10,700, were tested. The Co-operative General Science Test, Form P,[2] was given during the same week as was the Picture-test. This test has separate norms for those who have had chemistry and physics and for those who have not. I.Q.'s were obtained from the school records. No I.Q. more than two years old was used.

Some facts obtained were as follows:

1. Scores on the Picture-test were distributed on a curve not significantly different by the chi-square test from normal.

2. Some comparisons were made, in Table 1 (p. 364), among the various groups of pupils.

3. Some norms appear below following correlation data:

Minimum reliability of the Test (Kuder-Richardson)	0.784
Correlation of scores with I.Q. (product-moment)	0.392
Correlation of scores with those on Co-operative General Science test (product-moment)	0.533

(All above correlations have t ratios so high as to preclude chance occurrence at the 1 per cent level.)

[1] Described in E. F. Lindquist, *Statistical Analysis in Educational Research*, Houghton Mifflin Company, Boston, 1941. Chapter I.

[2] O. E. Underhill and S. R. Powers, *Cooperative General Science Test*, American Council on Education, Cooperative Test Service, New York City, 1939.

TABLE I

COMPARISON OF THE DISTRIBUTION OF SCORES ON THE PICTURE-TEST MADE BY THREE GROUPS: AND A COMPOSITE DISTRIBUTION INCLUDING ALL SCORES

Scores	Grades 8–12, No Maximum Science	Maximum Science	Talent Group	Composite of All Scores
36–37	.*	::	:	V:
34–35	:.	V:	:	VV:
32–33	V:	V:	::	VVV:.
30–31	V::	VVV	::.	VVVVV::
28–29	VVVVV.	VVV.	::	VVVVVVVVV.
26–27	VVVVVV	VVV	.	VVVVVVVVV.
24–25	VVVV::	V::		VVVVVV:.
22–23	VVVVV::	V.		VVVVVVV
20–21	VVVVV	V.		VVVVVV.
18–19	VV:.	.		VV::
16–17	V::	.		VV
14–15	::			::
12–13	:			:
10–11				
8–9	.	.		:
Totals	183	88	18	289

* *Key:* V's are five scores; (:) for two; (.) is one.

Adapted from several sources. Maximum science means either physics or chemistry or both. The Talent Group was the criterion, and consisted of 34 winners in state and regional Science Contests; 18 only being shown here.

TABLE II

NORMS

Norms Grade	M	σ	σ_M
Eight	22.50	4.85	0.707
Nine	24.12	4.76	0.894
Ten	25.62	4.67	0.953
Eleven	26.95	4.71	0.579
Twelve	26.33	5.32	0.731
Grade 8			
Urban	23.29	4.42	0.992
Suburban	21.7	5.11	1.07
Grade 9			
Urban	25.50	4.84	1.01
Suburban	22.75	4.26	0.888
Grade 10			
Urban	23.17	4.31	1.24
Suburban	28.08	3.53	1.02
Grades 11, 12			
Minimum science			
Boys	26.46	3.86	0.804
Girls	23.71	4.40	0.917
Maximum science			
Boys	29.54	3.71	0.577
Girls	25.20	5.69	1.040

A comparison of the first group of students used as a criterion, 18 members of a science group which won high honors in a state science contest, with the maximum-science group:

	Mean	σ	σ_M
Talent group	31.44	2.74	0.646
Maximum science	27.73	5.11	0.602

The t-test applied to these two means gives a t of 2.94. This is significant at the 1 per cent level. The groups are not alike.

The Picture-test was recently given to 16 winners in the Second Annual New England School Science Contest, chosen at random from 31 students representing winners from some 7,000 contestants. The mean was 32.14, the S.D. was 1.44, and the standard error of the mean was 0.601. This strengthens the hypothesis that "science-talented" young people score significantly higher on the Picture-test than do others. The test is now being converted to a paper-and-pencil form, and further confirmation of its ability to discover science talent will be sought through its administration to students who are known to be superior in the field of science. It is expected that the test will be ready for a large-scale tryout within a year.

4. Three measuring devices were used in the experiment. In Table 3 below are figures derived from scores on the Picture-

test, from I.Q.'s, and from scaled scores on the science achievement-test.

TABLE III

DATA FROM THREE TESTS GIVEN TO PUPILS PARTICIPATING IN THE EXPERIMENT

	N	Mean	σ_s^2	σ_p^2	σ_s	σ_m
Picture-test	271	25.36	26.27	26.37	5.13	0.312
I.Q.	271	108.98	214.98	214.98	14.64	0.830
Science test	271	49.32	174.70	175.34	13.21	0.803

Key for all tables: N or n, number of cases; σ, standard deviation or standard error; s, sample; p, population; M, mean.

Prediction Possibilities—Pupils in junior high school often show interest and ability in science. The Picture-test may be able to predict future success for these pupils in the more formal sciences of high school and college, and so fix in their minds the idea that they perhaps are potentially science majors. A great deal of care should be exercised here, as continuance with science also presupposes decided excellence in mathematics and high general intelligence. Science now is no longer a profession that calls only for ingenuity and for problem-solving capacity, although these are necessary. Science today is based almost wholly on mathematics at a very high level. While most able science students *do* go on with their studies, the saving of just one or two students annually for science may be important. The individual contributions of workers in the field of scientific research are sometimes important far beyond their quantitative value. As of today, there is, and will be for a decade, a serious shortage of scientists at a time when science problems are increasing exponentially.

Teaching with the Test—Not only can the device used here for picture-matching be used for testing, but it may be used as a teaching-device that will at least call attention to the nature of problem-solving activities. Subject-matter is relatively easy

to teach. Most teachers dealing with science-type material, together with the texts they use, profess to teach the scientific method. Most of them also would admit that they do very little such teaching, or if they claim so to teach, can show objective evidence of *incrementas* in the ability to solve problems by this method of careful thinking. And so many continue to teach a great deal of subject-matter, not only because it is easy to teach, but because it is easy to test results. Perhaps the Picture-test can provide material and method for the teaching of facts *and* scientific method, and then, having adequately pre-tested the ability to solve problems, measure small increments in that ability.

THE PICTURE-TEST A PROTOTYPE

Most important of all, this *type* of test may be applied to a variety of fields. All science-type subjects should find the form of the test valuable. Biological science, geography, health and medicine, safety, and others have real situations which might be photographed to provide innumerable items. In vocational and educational guidance, in the area of citizenship and ethics, and in the region of personal-problem solving, where relationships with other people are concerned, there should be fruitful research possible. If the study now completed has made a discovery, it is that another tool for the evaluation of human abilities has at least been found to hold an edge and to cut a small shaving cleanly.

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DEVELOPING PHYSICAL SCIENCE EXPERIENCES THROUGH THE USE OF COOPERATIVE GROUP PROCESSES *

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How can students be provided the kind of science experiences that will be useful to them in meeting their interests and needs? This problem grew out of the evaluation of results obtained by a fused survey course in physical science that had been in operation for several years. This course which consisted of units taken from physics, chemistry, geology, and astronomy had been taught by several experienced teachers who attempted to stress relationships and emphasize social values as well

* Based on the author's unpublished doctorate thesis, *Developing Physical Science Experiences at Madison College with Special Reference to Housing,* Teachers College, Columbia University, New York, 1948, 155 pp. Paper presented at the New York City meeting of The National Association for Research in Science Teaching, February 15, 1949.

as to cover a large amount of subject matter considered basic in the several fields. Teachers' marks and test results indicated very inadequate student achievement in terms of scientific knowledge and understanding. Students who had completed the course claimed they were confused, uncertain of the techniques taught, and unaware of any practical value of what they had learned. As many of the graduates who had taken the survey course were teaching in nearby elementary schools, they and their supervisors were interviewed. Their opinions were unanimous that the science course was of little or no value to the graduates either in their teaching or in their life in the community in which they lived. They avoided all science in their teaching because they felt unprepared to teach fundamental science concepts. Despite the emphasis the course placed on scientific method, the graduates could see no application for it in meeting problems within or outside the classroom. Administrators and supervisors stated that the graduates had not learned to recognize problems or to accept responsibility for solving them. The consensus of the opinions of the supervisors was summed up by one administrator, "Your graduates have just not developed the ability to accept responsibility, they are not aware of problems. Even when we outline problems for them they do not know how to go about a solution. The scientific method emphasized in your science courses remains only an outline on paper. It is not a part of their operative procedure."

This and other evidence gathered during a year and a half indicated the need for developing science experiences that would enable students to identify problems and to accept responsibility for devising and carrying through intelligent attempts to find solutions. In preparation for developing such experiences, it was decided to study the students, the community, and the results of curriculum building experiments reported in current educational literature

Students enrolled in this course during winter and spring terms were women seventeen to twenty-two years of age. During summer terms men and women somewhat older predominated. The majority of the students were sophomores preparing to teach in the elementary schools but a number of juniors and seniors in the pre-nursing, business, and liberal arts curricula elected the course. Most of the students had completed the traditional introductory course in general biology; only a very few had studied any other science at either the high-school or the college level. About two-thirds of the students came from rural areas. With a few exceptions they were residents of Virginia or of states farther south. Their activities in the college were strictly limited by college regulations which left them little opportunity for individual choices. The college program was quite rigid and most courses followed teacher-prepared outlines organized in terms of traditional subject matter. Success in the college depended on following the detailed teacher assignments and most students were very conscientious in doing assigned tasks. Elaborate procedures for checking in and out of dormitories, rigid attendance requirements, and strictly enforced rules regarding community activities and visits insured detailed college supervision of all the students' activities.

A survey of the local community disclosed serious problems in a number of areas. Outstanding was inadequate housing, particularly in the crowded slum sections existing in certain parts of the city. Transportation was inadequate. Other problems in the areas of health, in agricultural practices, industrialization, and nutrition were also found. Census data indicated these problems were typical throughout most of the state. Interviews with local city and county officials, leaders of civic organizations, and business men provided resources that students could use in the study of local problems. Files of

materials, booklets, and reports from government sources, colleges, and business concerns dealing with these subjects were developed.

The study of recent experiments in curriculum building provided little material that was useful. Most of the published studies in the science area recommended a fused or survey course similar to the one already established. In view of the results obtained, there seemed to be no reason to believe that broadening or further reorganization of the specialized subject matter would result in superior student growth. Everote's [1] reported study indicated that students' achievement improved with increased freedom to follow their interests, even within rather rigidly imposed requirements. Wickware [2] was also carrying on a significant experiment at this time developing a program based on "(1) the desires and needs of the students themselves, (2) the problems of the geographic area, and (3) scientific knowledge necessary to provide a rounded and more complete understanding of the role of science in modern society." Desires and needs of the students were determined by teacher-prepared questionnaires and the other factors were determined by the teacher's study and investigation. His procedures moved farther from the authoritarian philosophy than any other available reports, but the needs at Madison seemed to require larger freedom for student decisions. While accepting the principle that the criteria for selection of experiences must be derived from the immediate student-community relationships, it seemed desirable to give students experience in identifying as well as attempting the solution of problems real to them. The procedures most likely to produce the desired achievement seemed to be those implied by the philosophy of Experimentalism as described by Childs [3] in 1931. No reports of experiments in curriculum-building procedures based upon educational theories derived from this philosophy were available, a fact noted by Powers in 1945 [4] and again this past year.[5] However, it seemed obvious that (1) students could learn to identify and solve problems only by experience in attacking problems real and meaningful to them, (2) students could learn to utilize democratic group processes only through experience in democratic situations, and (3) student achievements in terms of knowledge and understanding would be superior if learned through application to situations important to the student. Hence, it was decided that students should be given maximum freedom in choosing and developing experiences as well as in evaluating results. The role of the teacher was planned to be that of a resource and consultant, using non-directive guidance techniques to promote student thinking and decisions. Teacher prepared questionnaires, outlines, assignments, and suggestions were avoided because they could hardly avoid being heavily loaded toward the teacher's interest.

At the first meeting of the class the students were told that the full resources of the department were available to them for study of problems in which they were interested and that they had full freedom to choose the problems and plan activities they thought most useful. After some dis-

[1] Everote, Warren P. *Agricultural Science to Serve Youth: Outcomes of a Course in Experimental Science for Secondary School Students.* Ph.D. Thesis, Teachers College, Columbia University, Contributions to Education No. 901, New York, 1943, 79 pp.

[2] Wickware, Robert K. *Developing Science Education with Regard for the Regional Community of Eastern Connecticut.* Ed.D. unpublished thesis, Teachers College, Columbia University, New York, 1947, 245 pp.

[3] Childs, John L. *Education and the Philosophy of Experimentalism.* New York: Century Company, 1931.

[4] Powers, S. R., and Blick, D. J. "Teaching of Science in Senior High School and Junior College." *Review of Educational Research,* XV (October, 1945), 301–308.

[5] Powers, S. R. "Introduction." *Review of Educational Research,* XVIII (October, 1948), 296.

cussion the group decided that each would prepare lists of problems in which they were interested. These lists were brought to class during the first week and a student elected secretary started copying them on the blackboard. Seeing the laboriousness of this process, several class members suggested a committee take all the lists, organize and classify them eliminating duplications, and prepare a report for group discussion. This procedure resulted in a list of problems classified as follows:

1. The production of materials and equipment which people need or desire.
2. The solution of transportation problems.
3. Problems of housing.
4. Problems of communication.
5. Understanding the universe.
6. The improvement of individual and community health.

After considering the report the group discussed methods they could use to consider the problems. They decided to choose a committee to take charge of each area of work and that the committee which made the report should constitute a planning committee to correlate and facilitate the over-all program. Various students and groups volunteered to undertake investigations and studies within the outlined plan. For instance, in the study of problems of housing, different groups studied such topics as zoning, how to select a site for a house, selection of materials for exteriors and interiors, house plans, electrical wiring, illumination, heating and ventilating systems, plumbing and sanitation, and costs of building. Groups investigated the local housing situation and interviewed local authorities on problems, their causes, and possible solutions. The laboratory was used in testing building materials for such characteristics as strength, hardness, corrosion, fire resistance, and heat conductivity. Model heating systems were built and operating systems in homes were studied. Illumination surveys were made and lamps and lighting fixtures were studied in the laboratory. The college geologist aided in the study of rock formations and excavation problems. Reflection of colored paints was measured. Efficiency of various makes of appliances was determined. A solution to a particular problem usually led to awareness of other problems resulting in continuous broadening and deepening of the student interest. Individuals and committees studying particular problems made frequent progress reports to the class and the group discussion resulting became increasingly critical and rich in suggestions for further study.

During these activities the teacher participated as a member of the group reflecting summaries of group discussions back to the group for further consideration or decision, making resources available, conferring with committees and individuals, and giving assistance in use of laboratory equipment or unfamiliar procedures. He observed the work of the students, noting where difficulties occurred and kept anecdotal records as one basis for judging progress. The group met the problem of evaluation of group and individual achievement through techniques of group action. A committee report on evaluation was discussed, revised, and adopted. Students participated in measuring achievement in terms of knowledge, understandings, skill, initiative, change in attitudes, and ability to function within a group through development of tests, score cards, and check lists.

Unfortunately it was not possible to follow up these students in sufficient detail to compare their activities after graduation with those of former students. However, there was a great deal of evidence of superior achievement by the group. The test results indicated much higher achievement in terms of scientific knowledge. Their work in other courses and in the demonstration school indicated keener interest in science and readiness to attack problems through rational procedures.

Anecdotal records showed that fear and avoidance of scientific data and concepts were replaced gradually by understanding and utilization of all available material and the use of democratic techniques. The passive acceptance of decisions made by superior authorities was replaced increasingly by attitudes of inquiry and intelligent skepticism. Hesitation in attacking new problems diminished while eagerness to investigate new interests increased. Habits of completing assignments for the teacher were replaced by cooperative activities and participation in group action. Original interests, sometimes superficial and narrow, grew deeper and broader as experiences brought increased awareness of their ramifications and implications.

This experiment seems to indicate that experiences based on educational theories derived from the philosophy of experimentalism can result in student achievement superior to that obtained through authoritarian procedures, even within the framework of a traditional college program and in a conservative community. There is need for further experimentation in this direction, particularly in situations allowing greater all college and community participation. In this age when democracy is challenged by opposing philosophies, it is imperative that our citizens be better prepared to utilize group processes intelligently and effectively. Education in the science area, which has had a large part in the posing of critical problems for society, has hardly begun to deal directly with the problem of educating citizens in the use of scientific techniques for meeting those problems.

While this study dealt largely with the education of the non-specialist in science, the need for experimentation in the education of the science specialist is clearly indicated. Students preparing to be engineers, doctors, chemists, or physicists surely have keen interests in the chosen fields which might well be the basis for the development of meaningful experiences. If activities derived through group processes resulted in clearer understandings and wider as well as more rigorous achievement for the non-specialist, it is at least likely they would be equally effective in training the specialist. In fact, procedures approaching in practice those described are used during the advanced years in engineering and medical schools, but their development in the undergraduate and high school levels awaits pioneering experimentation. Participation in group action in a democratic climate might well avoid the development of the reactionary social attitudes typical of some professional groups.

Operation of educational procedures consistent with the philosophy of experimentalism requires a degree of competence teachers are not likely to develop through teacher education programs based on authoritarian philosophies and traditionally organized subject matter. Techniques for operating within the group and dependence on non-directive guidance are foreign to methods employed in most of our college science classrooms. The teacher loses the security of the syllabus, textbook organization, and the authoritarian assignment with pre-determined answers. Subject matter is not limited by his prescription and demands on the expertness of the teacher in his subject matter field far exceed those of traditional specialized courses. In addition, demands on the teacher's time, practical knowledge of psychology, and willingness as well as competence in using democratic techniques are excessive. If the teaching staff has opportunity to solve these problems through participation in group processes, transition to such techniques in their teaching should not be too difficult.

The experiment described in this article does not supply ready made answers that can be applied to all situations. It is hoped that the degree of success obtained will stimulate others to develop and modify the techniques to fit the needs of other situations and to carry on further experiments based on educational theories derived from the philosophy of experimentalism. One

of our leading weekly news magazines remarked recently, "No U. S. citizens are fonder of praising democracy than the heads of that most authoritarian institution—the U. S. school." If science education is to supply the tools which citizens will use to develop democratic solutions to the problems of our technological society, then the time for action is indeed later than present practices indicate.

A COURSE OF STUDY IN ECONOMIC ZOOLOGY FOR STUDENTS OF AGRICULTURE AT THE VIRGINIA POLYTECHNIC INSTITUTE *

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THE PROBLEM AND ITS SETTING

THE course of study described in this paper was designed to replace a course in economic zoology which for some twenty years has been required of certain students of agriculture at the Virginia Polytechnic Institute, a land-grant college. The course is offered in the first quarter of the sophomore year. It is preceded by three-quarter freshman courses in general biology, general chemistry, and English; two-quarter courses in mathematics and sociology. In the sophomore year it is followed by courses in anatomy and physiology of domestic animals, and parasites of domestic animals. All of the students have a full year of physics as sophomores, and some take organic chemistry in the second or third years, as well as genetics and additional mathematics. The students take a one-quarter course in diseases of domestic animals during the junior year, and some take a course in applied entomology in the senior year. Several "professional" courses in animal husbandry, nutrition, and management are required in the various agricultural curriculums, principally during the junior and senior years.

The course which has been replaced was "traditional", in that it was subject-matter based, and was presented in the usual lecture-laboratory manner. Attempts had been made to make it supplement the freshman course in general biology, and it was expected that the course would contribute something to preparing the students for their advanced courses in zoology and in their professional fields. Results of questionnaires filled out by former students indicated, however, that neither of these objectives had been met satisfactorily. Considerable effort was made in revising the course to improve it in both these respects. A study of the relationships which should exist between the freshman course in general biology and the course in economic zoology indicated that the latter could effectively supplement the freshman course by emphasizing the application of biological principles to the solution of real and practical problems, although it was realized that employing the problem approach in the general biology course itself would seem to be sounder procedure. A real attempt has been made during recent years to make the freshman course more functional, and it is expected that the experience of those who are concerned with the revision of the course in economic zoology will ultimately facilitate a more effective reorganization of the whole program in zoology.

* Paper presented at the New York City meeting of The National Association for Research in Science Teaching, February 14, 1949. Based on the author's doctoral study at Teachers College, Columbia University, *A Course of Study in Economic Zoology for Students of Agriculture at the Virginia Polytechnic Institute.*

OBJECTIVES OF THE COURSE

By means of a questionnaire, supplemented by interviews and correspondence, it was learned that each of the heads of the major departments whose students take the course in economic zoology (1) thought that the course could be organized and presented so as to serve as an effective introduction to advanced professional courses; (2) believed that the proposed course should and could contribute to recognized objectives of general education; (3) thought that the course should be organized around practical problems; (4) believed that college and community resources such as breeding barns, the college dairy, and the packing houses should be used to help provide meaningful experiences to the students; and (5) offered the facilities of the department concerned to help achieve these goals.

The department heads all agreed that the course could and should contribute to achieving at least four of the objectives of general education developed by the President's Commission on Higher Education. These four objectives, listed as Nos. 4, 7, 10, and 11 in the Commission's report [1], read as follows:

> To understand the common phenomena in one's physical environment, to apply habits of scientific thought to both personal and civic problems, and to appreciate the implications of scientific discoveries for human welfare.
>
> To maintain and improve his own health and to cooperate actively and intelligently in solving community health problems.
>
> To choose a socially useful and personally satisfying vocation that will permit one to use to the full his particular interests and abilities.
>
> To acquire and use the skills and habits involved in critical and constructive thinking.

For some years there has been an increasing concern at the Virginia Polytechnic Institute about general education. Records of alumni demonstrate generally that if graduates of Virginia Polytechnic Institute are to achieve a general education, the Virginia Polytechnic Institute must give it, or at least must help the student to achieve it.

A study to determine how the course in economic zoology might help meet the professional needs of students of agriculture was greatly facilitated by Professor H. W. Sanders, Head of the Department of Vocational Education at the Virginia Polytechnic Institute. Professor Sanders provided a comprehensive report of a study he had made in 1944 concerning "subject matter deficiencies and professional training needs" recognized by agricultural education graduates who were teaching vocational agriculture. While some of the skills listed by these teachers called for little more than the dexterity which would usually result from learning and practicing specific operations, biological principles are involved in most of them. The first three skill-needs listed under *Dairying* were: (1) Treating for milk fever; (2) Treating bloat; (3) Balancing rations. Obviously all three are problems which are related to the materials of zoology. Since the students will have a course in diseases of domestic animals following that in economic zoology, any extensive discussion of the first problem probably should be deferred. In some instances, the proper solution of the agriculture instructor's problem includes the realization that he has not had the training and experience to diagnose and treat some diseases. An important part of the instruction of some students is bringing them to a realization of the limitations of their knowledge. The second problem, however, offers definite possibilities for economic zoology, since bloat, while "a disordered condition of the body", occurs simply because of cessation of gas elimination from the rumen. There are several reasons why a consideration of bloat in cattle, a *real* problem to every farm youth, might be included in a study of invertebrates which serve as part of a food chain leading to man. Rumen fermentation is a live problem at all agricultural colleges and experiment stations. It illustrates how many biological problems involve areas in the fields of both the biological and physical sciences. The problems of bloat may not be solved in the economic zoology laboratory, but their

consideration can lead to a better understanding of chemical changes, nutrition, of past contributions to science, and of prospects for future achievement. Such understanding may help provide "those visions of greatness" which the advocates of liberal education tell us that students must have if they are to be able to distinguish greatness from mediocrity.

Along with providing as much experience as possible in the consideration and solution of real problems, the laboratory and field work of the revised course has been planned to give all the group planning experience possible. Practice in group planning and group problem-solving must certainly contribute to such general education objectives as helping students to participate actively and cooperatively in public affairs. Ability and experience in group work are so important to future teachers, county agricultural agents, and rural leaders generally, that group planning experience can also be listed as a special or professional need of agriculture students. In this connection it is interesting to note that cooperative enterprises have had their greatest development in the United States among those "rugged individualists", the American farmers. Consider the Soil Conservation District program, under which a District is organized as a governmental unit after affirmative results of a referendum requested by the farmers themselves. These Soil Conservation Districts make large demands for intelligent cooperation among farmers. Profitable experiences in group work at college should help graduates to give effective leadership-participation to such programs.

GENERAL ORGANIZATION

At the end of this paper is a "Suggested Procedure for Group Work in Problem Solving" which was used in the economic zoology classes in the fall of 1948 to help introduce the students to group work. Among the problems selected by the eighty students who took the course were the following: Meat Curing; Control of "Skippers" in Cured Meat; Egg Preparation and Storage; Gambusia Minnows as Mosquito Controls; Fur Farming as a Supplementary Farm Enterprise; Artificial Insemination; Hybrid Cattle and Hogs; and Game Management on the Farm. The twelve-week course comprised two lecture periods and one three-hour laboratory period each week. Approximately half of each laboratory period was used to discuss and demonstrate the structure and physiology of economically-important members of important phyla. The textbooks used were Storer's *General Zoology* [2], and Fitzpatrick's *The Control of Organisms* [3]. Lectures, supplemented by text assignments, readings from other books and periodicals, and mimeographed notes, were organized as follows:

I. Animals Useful to Man: Their Production and Management (5 weeks)
   A. Animals as sources of food
   B. Animals as sources of other materials of commerce
   C. Animals which provide recreation, esthetic enjoyment, and materials for scientific studies
   D. Animals which serve as controls of noxious organisms
   E. The domestication of animals
   F. Genetic improvement of animals

II. Animals Which Are Economically Detrimental to Man: Their Control (3 weeks)
   A. Animals which are vectors of disease among useful animals
   B. Animals whose habits put them in competition with man for food and other products

III. Animals Which Are Dangerous to Man: Their Control (2 weeks)
   A. Parasitic animals which produce disease in man
   B. Animals which spread diseases of humans
   C. Animals which are venomous

As has been stated previously, the students are scheduled for later courses

entitled *Parasites of Domestic Animals, Diseases of Domestic Animals, Anatomy and Physiology of Domestic Animals,* and *Genetics.* Hence, less time is devoted to a consideration of parasites and some other groups than would otherwise be given.

EVALUATION

An evaluation of the results of the course as given is being attempted. In some instances it seems evident that more help should have been given to individuals and groups in the selection of their problems. Further study may indicate that the course should be combined with other courses, or possibly that a general revision of several courses is desirable. It seems reasonable, however, to believe that the problem approach offers real possibilities toward vitalizing the course, and that specific attention paid to group planning and group work is definitely worth while.

Is there anything new in this revised course? In his later years T. H. Huxley wrote that the objects he had had before him through most of his life were " . . . . to promote the increase of natural knowledge and to forward the application of scientific methods of investigation to all the problems of life to the best of my ability, in the conviction which has grown with my growth and strengthened with my strength, that there is no alleviation for the sufferings of mankind except veracity of thought and action, and the resolute facing of the world as it is when the garment of make-believe by which pious hands have hidden its uglier features is stripped off."

ECONOMIC ZOOLOGY—FALL, 1948

SUGGESTED PROCEDURE FOR GROUP WORK IN PROBLEM SOLVING *

1. Select an area in which the group is actively interested. It might be, for example, that of Home Preserving of Meat. (It may be possible for the group to agree immediately on a problem that is real and important to each group member. In that event, your next step would be that described in Section 3.)

2. In group discussion, formulate questions concerning the area; real questions to which you would like to have answers. The following may serve as examples: Why do some home cured meats spoil? Why are some hams too hard and too stringy? Is dry salting better than brine salting? Must temperatures be controlled while meat is curing? If so, what variations are allowable? Does smoke have any preservative value? Does liquid smoke produce as good a product as actual smoke? Does sugar inhibit or encourage spoilage? What makes ham or bacon become rancid? Is it necessary for a ham to be aged to be at its best? Should hams be wrapped in airtight coverings? How fat should a prime ham be?

3. Resolve your questions into a problem that can be stated definitely and placed in a setting of which you are a part. Your problem might read like this: How can home-cured hams of uniform quality be insured, under average conditions in Virginia?

4. Write down what you already know that might contribute to a solution of the problem. Then review the literature on the subject. Government bulletins will be available on many subjects. Interviews with authorities should be used where practicable. Possible sources of information should be discussed by the group, and plans made for utilizing them efficiently with each member of the group contributing his part.

5. After you have acquired sufficient information to allow you to proceed confidently, discuss your data and propose a tentative solution to your problem. In doing this, you are "formulating an hypothesis"; you are making an intelligent guess which you will test to see if it is valid. If your problem were on the preservation of meat products, you would develop a proposed process which you thought would produce satisfactory results.

6. If your hypothesis is one that you can test through laboratory or field observations, use this method. Be sure to record your results accurately, fully and intelligibly. Do your results substantiate your hypothesis? Are there any evidences which indicate that while your hypothesis stood up under the tests you applied to it, it might not withstand other justifiable tests? Do not be discouraged if your experimental data demonstrate that your hypothesis is wrong. If you have recorded your results honestly and clearly, you at least have saved another group from making the same errors you have made. Now you shall have to try again by formulating another hypothesis.

The foregoing paragraph may suggest how you can test your hypothesis through reference to the literature, or through conference with other workers. Others may already have either proved or disproved your hypothesis. If the

* Adapted from an outline for group work designed by Professor S. Ralph Powers, Teachers College, Columbia University.

results of their work are available in writing and if you are sure that they are competent, honest workers, you can apply their results to your own problem. The professional research worker usually makes every effort to find out if someone else has worked on his problem, or a similar one, before he formulates his hypothesis. In some instances, however, he may formulate such an hypothesis, at least mentally, before he has exhausted all the possibilities of the literature.

The problem of home curing meats might be solved without the conscious formulation of an hypothesis. The answer might be directly available, either from the literature or from experts who could be interviewed. In this event, some previous worker or workers would have gone through the procedure of making the necessary scientific tests.

Research workers would probably list the steps in the scientific method something like the arrangement below:

1. Object or statement of problem.
2. Review of literature, to find out all that is known concerning the problem.
3. Statement of the hypothesis; the investigator's guess as to the solution of the problem.
4. Procedure, or testing the hypothesis.
5. Results.
6. Conclusions.

The general procedure of the method of scientific thinking is the same, whether the problem be "How can I cure my hams satisfactorily?" or "Shall I get married while I am still an undergraduate?"

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A STUDENT TEACHING PROGRAM DESIGNED TO BRIDGE THE GAP BETWEEN THEORY AND PRACTICE *

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EDUCATORS in teacher colleges throughout the country have been trying desperately to bridge the gap between the stages of theory and practice. In too many instances the student teacher is placed in a position which presents many artificial and protracted situations such as: not having full responsibility for the success of his teaching; teaching only students who are average or above and present no problems of adjustment; not being permitted to carry a complete teaching load; stepping into a situation where he is recognized by the students as an inferior substitute whom they must endure for a certain number of class periods during the semester; or taking over as a regular teacher, with little or no supervision. As a consequence, a majority of our beginning teachers enter the profession inadequately prepared to meet the many diversified problems they face upon entering their classrooms for the first time.

This paper describes a program for student teaching at Teachers College, Columbia University, and a part of the program at Plymouth, planned to bridge the gap between theory and practice. The individuals participating in the program at Teachers College, Columbia, were, for the most part, graduates of liberal arts colleges and had not decided upon a career in education until after completing their undergraduate work. Their field of specialization was, therefore, largely completed by the time they decided to become teachers. Education in a democratic society, the teaching-learning process, and application to actual teaching situations through student teaching were courses and experiences

* Paper presented at the New York City meeting of The National Association for Research in Science Teaching, February 14, 1949. Based on the author's doctoral study at Teachers College, Columbia University, *A Cooperative Program for Student Teaching Involving a Private College and a City School System.*

which remained before completing the teacher preparation program.

A study of student teaching in the Natural Science Department at Teachers College, Columbia, in 1946 revealed that the program in force did not seem adequate for bridging the gap between theory and practice. Teachers College has used the schools of New York City for its student-teaching program, and the first step in instituting a revised program was to visit the schools and select those interested in the best education possible, and in helping with a plan to train more competent beginning teachers.

Each individual who was to do student teaching the second semester was called to a conference with the supervisor of student teachers in November, at which time the student's educational background, his educational point of view, and the type of school in which he wished to teach upon graduation were ascertained. Schools that could provide the type of experiences suited to the student's needs were selected. It was explained to each student that student teaching would be his most important course during the following semester and he was asked to budget adequate time for complete experiences in this work. He was asked to plan visitation of the classes in the school selected at least twice each week for a month before the end of the first semester of school. In nearly every instance the student was taken to the school and introduced to the head of the science department and, after a conference, was assigned to a regular teacher with whom he was to work.

By the end of a month of observation, each student teacher was actively helping his critic teacher by grading papers, preparing bulletin boards and show cases, preparing tests and records, and checking equipment. He was analyzing the planning and teaching of his critic teacher and discussing it with him in daily conferences. Since the student teacher was present at the close of a semester, he gained experience in the technique of ending a semester's work.

The first week of the second semester was largely spent in preparation for teaching the classes assigned. Each student teacher was assigned to a class in general science, and a class in either biology, physics, or chemistry, which he was to observe and teach. Before any actual teaching was done, however, each student teacher was expected to make a study of the individuals in his classes, observing each student and noting his personality characteristics, learning his interests and needs by observation and conversation, and using the files of the school to obtain any further information.

In every instance actual teaching had begun early in the second week. The first class taught was one of a unit planned by the critic teacher. This lesson, as well as the majority of those subsequently taught, was carefully evaluated by the critic teacher and the student teacher in conferences which they held almost daily. They were concerned with such things as adequate planning of the lesson with consideration for personality characteristics, interests, and needs of the students in the class; the organization of the material discussed; the adequacy of the demonstrations; and adequacy of the questioning. Wherever it was possible, the student teacher next taught the last lessons of one unit and introduced another unit. The frequency of teaching gradually increased until complete units of work in two subjects were taught. In the majority of cases the student teacher handled a full load of teaching for two or three weeks near the end of the semester.

The student teacher was expected to spend at least four or more hours in the public school each day. He gained a variety of experiences besides observing and teaching, such as attending all departmental and staff meetings, helping with science clubs, working in laboratories, etc. Several student teachers actually participated in the departmental meetings by preparing and

giving papers. All but two student teachers assisted with science clubs, while four student teachers organized and advised science clubs in their cooperating schools.

All of us are aware that a unit of work can be meticulously planned and carefully taught, but unless the teacher recognizes in the planning the level of the pupil's experience, his needs, and his problems in adjustment, the teaching will be a failure. Therefore, each student teacher was required to select at least one (most selected several) unadjusted child for special attention. After studying the child by observation and conference, and through utilization of all available records, he devised a plan for helping the child become adjusted. The following is representative of the work done by the student teachers:

The pupil, a boy seventeen years old, was in a biology class. Five years ago this boy, while playing around high voltage cables, was seriously injured. One side of his body was badly burned and disfigured. His sight was impaired. The electric and nervous shock left their permanent marks. After the accident he spent approximately a year in the hospital, slowly regaining his strength and his ability to live a partially normal life. While he was in the hospital, his parents seldom came to visit him since both of them were working. When they did come, they gave him little encouragement. More frequently they left him feeling that he had become a great expense to them. He gained the impression that he was not wanted and loved.

When the boy returned to school, his regular class was ahead of him and he had to form new friendships, which was difficult because of his bodily disfigurement. He became melancholy and lost self-confidence. Although his I.Q. was slightly above average, he was not doing acceptable work at school. States of depression frequently forced him to return to the hospital.

These, in brief, were the findings of the student teacher when she began studying the boy. The boy's condition, caused by lack of interest on the part of the parents, the feeling that he could never support himself and would be a burden to society, the loss of most of his friends, and unsatisfactory school work, had made it necessary for him to return once more to the hospital. The student teacher indicated her interest in him by visiting him regularly and supplying him with books and magazines. When he became well enough, she discussed his lessons with him and helped him to keep pace with his classes. In the meantime she had talked with the parents, and her interest in their son gave them encouragement which was reflected in their attitude toward him. When the boy returned to school, he and the student teacher discussed vocations that would be possible and profitable for him. Continued interest on the part of the student teacher and other teachers, who had since become interested, were showing their effects on the life of this boy. His outlook on life was changing and he was gaining new friends in spite of his physical handicaps. His school work also improved considerably.

In the laboratories the student teacher became acquainted with the most important demonstration materials to be used, and the storage and maintenance of such material. The student teacher gained experience selecting and using 3¼″ x 4″ as well as 2″ x 2″ slides, and 16 mm. sound and silent film. He was able to learn sources from which these and other teaching aids might be obtained.

Accompanying this program at the various schools was a two-hour seminar at the college each week, during which the student teachers discussed their problems encountered in student teaching. Each student teacher had almost daily conferences with his critic teacher or teachers, and an individual weekly conference with his college supervisor, at which time individual problems were discussed and solved, but problems common to many of the student teachers were constantly discovered, and the entire group of twenty-one student teachers studied and suggested solutions to these problems in their weekly seminar.

The results of the program indicated that student teaching should be the central course around which much of the preparation of the areas of psychology, principles of education, and methods of teaching are planned instead of being a course climaxing the theoretical preparation for teaching and thus attempting to put into operation the many principles studied vicariously. Such a program would call for student teaching much earlier in the teacher preparation curriculum.

Because the results of this study and program were encouraging, and because they pointed toward earlier contact with children, arrangements were made to have

as many as possible of the students at Plymouth Teachers College gain an early experience with the teacher-learning situation. Last year arrangements were made with teachers in the laboratory school to have students from the course, Introduction to Physical Science, work with them in their teaching of science. Not all teachers cared to participate, and they were neither urged nor asked a second time.

The plan called for the student to observe the teacher and pupils working together with situations of a scientific nature. Each student participating in this program (not all desired to participate, nor did we have facilities to handle all of them) was expected to report what he had observed in a weekly conference with his college instructor. Here the class work was discussed and evaluated. Toward the end of the semester the conferences included the teacher in the laboratory school. Attention was directed to the teaching-learning process, the type of pupil-teacher planning, the methods of evaluation, the use of interests of pupils in the class, the response and interest of the pupils in the class, the reactions of the pupils, with particular emphasis upon the reactions of the low and high I.Q. children, and the type of science experiences provided in the particular grade level.

The student was expected to help the teacher in any way possible. Planning demonstrations, setting up demonstrations, helping the slow pupil, demonstrating to small groups and perhaps later to the entire class, and helping on field trips were activities engaged in during last year. This year the program has been expanded to include more intimate work with children. The students are working with small groups, aiding them in planning their unit of work, helping them find materials, planning and taking field trips, helping the pupils discover suitable experiments to solve problems, and organizing their work for sharing with the other pupils through class participation.

One need only make two observations to realize the program has been successful. More teachers in our laboratory school are participating this year, for several asked to be included. More students are asking for this opportunity. The results of this work are being useful in courses in Childhood Education, Psychology, Educational Psychology, and Guidance.

Besides providing real experiences for discussion in professional courses, other values have become evident. Many students in the two-year General Education program at Plymouth Teachers College are undecided as to their choice of vocation, and several good prospects for teachers have been secured by this experience. Individuals have also been discovered who can not easily adapt themselves to the teaching profession or who must be guided into some special phase of teaching.

It was, as expected, found that to gain needed competencies for teaching, varying amounts of experience in actual teaching situations must be provided. At present, the school is not in a position to measure the degree to which this program helps the student in his student teaching because most of those participating are or have been freshmen or sophomores.

A new emphasis and interest in science is evident in the laboratory school. The elementary teachers are becoming less afraid to teach science, and as a consequence they are putting more emphasis upon this phase of the child's education.

From the results of the program at Teachers College, Columbia University, and at Plymouth Teachers College, it appears that a measure of success has been attained in bridging the gap between theory and practice in the program of teacher education.

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BOOK REVIEWS

VAN CLEEF, EUGENE. *Our Modern World.* Boston: Allyn and Bacon, 1949. 461 p.

Our Modern World is a high school textbook in global geography. Secondary geography is an area that needs an increased emphasis. Never before has there been a greater need for a better understanding of the responsibilities and complexities of national and international leadership. Surely the experiences of World War II and the American assumption of leadership in world opinion are valid reasons for the inclusion of courses or areas of study that provide a more intelligent approach to regional, pan-American, and world understanding. Seemingly school administrators and curriculum makers have been slow to emphasize an area so badly needed if better social understanding is to result. Not too many good secondary geography texts are available to meet the needs in this postwar responsibility.

Our Modern World does meet these needs in a most practical way. It combines physical, economic, commercial, and political geography in an unusually fine way. The regional point of view has been utilized. The emphasis is upon peoples and their geographic settings, their products, ways of making a living, and probable future.

The reviewer especially likes the excellent pictures, charts, maps, and pupil questions, activities, and problems. Statistical information and political boundaries have been brought up to date. The appendix has twenty-five pages of useful statistical information, followed by a well-selected teacher-pupil bibliography. Altogether this is a book that will appeal to both teachers and pupils alike. In no other course can students obtain so much general education and knowledge of the world in which they live with relatively so little expenditure of time and energy, yet so challenging to their interests and capabilities.

C. M. P.

HUNTINGTON, HARRIET E. *Let's Go To The Desert.* Garden City, New York: Doubleday & Company, Inc. 1949. 89 p. $2.50.

Many readers will recall with delight the author's earlier *Let's Go Outdoors* and *Let's Go To The Seashore. Let's Go To The Desert* is an equally delightful book for the third or fourth grader. The textual material is given in simple terms and interesting style. Beautiful, artistic pictures in sepia are found on each right hand page. Elementary science teachers will be delighted to have this book on the elementary science book shelf.

C. M. P.

MCCLUNG, ROBERT M. *Sphinx.* New York: William Morrow and Company, Inc. 1949. Unpaged. $2.00.

This is a picture-story book of a caterpillar. It shows every step of his development and how he looked at each stage. The story is told in

simple language with a picture for every page. The author is assistant in the Department of Mammals and Birds at the New York Zoological Park.

In reading difficulty the book is about third or fourth grade level but upper levels will enjoy reading it. This is an excellent book for the elementary science book shelf.

C. M. P.

ZIM, HERBERT S. *Snakes.* New York: William Morrow & Company, 1949. Unpaged. $2.00.

This is a Morrow Junior Book by one of America's best known popular science writers. Other recent books by the same author include *Homing Pigeons, Rabbits, Elephants,* and *Goldfish.*

North American snakes are described as to habits, habitats, reproduction, growth and movement. Much useful information is given as to differences between poisonous and non-poisonous snakes, how to treat snake-bite, growth of snakes, food habits, handling and keeping snakes, and so on. There are numerous illustrations by James Gordon Irving.

C. M. P.

MASON, GEORGE F. *Animal Weapons.* New York: William Morrow and Company, 1949. 94 p. $2.00.

Animal Weapons is another of the Morrow Junior Books and in difficulty is suitable for the junior high school or upper intermediate grades. The author is a member of the staff of the American Museum of Natural History in New York City and is well remembered for his earlier *Animal Tracks, Animal Homes,* and *Animal Sounds.*

The material is presented in a most readable and interesting style supplemented by numerous illustrations by the author himself. Weapons used by animals include horns, antlers teeth, tusks, hoofs, nails, claws, talons, quills, spines, fins, poison, odor, shocks, stings, and so on.

This is a delightful elementary science book that will be a pleasure to the pupil and the teacher.

C. M. P.

SCHNEIDER, HERMAN AND NINA. *How Your Body Works.* New York: William R. Scott, Inc., 1949. 160 p. $2.50.

How Your Body Works answers many questions about their bodies that young people want to know. The human body is the most complex machine and laboratory that we know. Textual material is supplemented by numerous drawings and many interesting experiments. There are more than twenty experiments which pupils can readily do themselves. Every major point is illustrated with drawings of healthy boys and girls in action.

The Schneiders are authors of the earlier well known science books *Let's Find Out, Now Try This, Let's Look Inside Your House,* and *How Big Is Big?* Herman Schneider is a science coordinator in the New York City Public Schools.

This book is recommended as an excellent addition to the elementary science and junior high school book shelf.

C. M. P.

NATIONAL EDUCATION ASSOCIATION OF THE UNITED STATES. *Proceedings of the Eighty-Sixth Annual Meeting Held at Cleveland, Ohio, July 5–9, 1948.* Washington, D. C.: National Education Association, 1948. 463 p.

The report consists of addresses, minutes of business meetings, department reports, annual reports, and associational records and information.

C. M. P.

BUROS, OSCAR KRISEN: *The Third Mental Measurements Yearbook.* New Brunswick, New Jersey: Rutgers University Press, 1949. 1047 p. $12.50.

The Third Mental Measurements Yearbook is a most impressive and comprehensive volume. The page size is slightly greater than 7 x 10, the print smaller than most publications, and the more than a thousand pages are tangible proofs of the great amount of labor and time spent in this compilation. Even the first typing and reading, and the galley reading and proofing constituted an unbelievably great expenditure of time and energy, and patience. The author, his assistants, and the publishers are to be highly commended for publishing such a comprehensive treatise.

Tests of every kind are listed and described—achievements, character, and personality, and subject matter tests. The latter includes the various science tests. Also more than two hundred pages are devoted to evaluation of books on testing. "Tests and reviews" list 663 tests, 713 original reviews by 320 reviewers, 66 review excerpts and 3368 references on the construction, validity, use, and limitations of specific tests. "Books and reviews" lists 549 books on measurements and closely related fields and 785 excerpts from reviews of these books in 135 journals. The period for book reviews covers October, 1940, to December, 1947.

There is a publishers directory and index, a periodical directory and index, index of titles, index of names, and a classified index of tests.

This yearbook should be of value to many different types of workers, and as an excellent reference to teachers on all levels who may be interested in knowing about or using certain specific tests.

C. M. P.

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